

CHAPTER 3

PLUMBING

LEARNING OBJECTIVE: *Recognize proper tool accountability and safety; recognize procedures for laying out wastewater systems, water distribution systems, and joining different types of piping; and recognize accessories used in their construction.*

Plumbing plays a major role in the construction of all types of residential, commercial, and industrial buildings. Of all the building trades, plumbing is most essential to the health and well-being of the community, in general, and to the occupants of the buildings in particular. It is an obligation and responsibility for each and every Utilitiesman to uphold the vital trust placed in him or her for proper installation of plumbing materials and equipment. Each plumbing installation is governed by the rules and regulations set forth in local plumbing codes that have been adopted from standards established at the local, state, and federal level. As you progress in rate as a Utilitiesman, it becomes your job to ensure that codes established for the job are carried out. You may soon be the supervisor or instructor responsible for training Utilitiesmen under you.

In this chapter you are introduced to the tools required for plumbing and to the different types of materials used in underground and aboveground piping. You will discover where, why, and when to use certain materials during installation and repair of these piping systems.

TOOLS

LEARNING OBJECTIVE: *Recognize the importance of tool accountability, types of tool kits, and methods of their use and safety.*

To install various types of equipment, you will use many different hand tools and power tools. For the purpose of safety, you should understand the major importance of using the proper tools for the proper job. For a complete and thorough understanding of various tools, read the training manual, *Use and Care of Hand Tools and Measuring Tools*, NAVEDTRA 12085. The following tool kits are available to the Utilitiesman

from the Naval Construction Force, Table of Allowance (TOA):

80001 Kit, Plumbers: This kit contains the basic equipment and hand tools required for field installation of various plumbing systems.

80002 Kit, Plumbers Shop: This kit contains the basic equipment and hand tools required for establishing a base maintenance plumbing shop.

80005 Kit, Service Refrigeration: This kit contains the basic equipment and hand tools required for routine maintenance, recharging, and repair of various types of refrigeration units.

80055 Kit, Cast-Iron Pipe Installation: This kit contains the basic equipment and hand tools required for installation of cast-iron piping.

80088 Kit, Power Threading: This kit contains a power threader and all of the attachments to place threads on pipe material.

TOOL ISSUE

You may be required to draw tools from the central toolroom (CTR) or the central storeroom (CSR). Procedures for issue and accounting of tools and replacement of broken or missing tools are established in the *Seabee Supply Manual*, COMTHIRDNCB/COMSECONDNCB 4400.3. You are responsible for the following:

- Maintaining the complete tool kit for which you signed
- Using and caring for tools assigned to you
- Preserving those tools in use and those not in use
- Securing assigned tools
- Accounting for tools

- Seeing that tools are returned to their proper place at the end of each day

A requirement to conduct a biweekly inventory/inspection ensures that tools are maintained and ready for use. Whenever you have missing, broken, or worn-out tools, submit NAVSUP 1250-1, signed by your division/company commander or chief, for replacement. You may also be required to start action on a survey form (NAVSUP Form DD 200) for lost, destroyed, or damaged by other than normal wear. For help in filling out these forms, ask your crew leader, first-class supervisor, or chief.

TOOL USE

When using tools, use them the way they were designed to be used. Adjustable wrenches should not be used as hammers; screwdrivers should not be used as chisels, and so forth. Not only can you damage what you are working on, but you can injure yourself or someone else. Keep tools clean and free of grease, oil, and dirt. When you are through with a tool, put it back in its proper place. Tools requiring maintenance must be turned into CTR/CSR for immediate replacement. Do not take chances. For instance, a chisel with a mushroomed head where the mushroomed portion of the head has just the slightest split when struck with a hammer, a piece of the metal may become an airborne piece of shrapnel. Normally, preventive maintenance is performed on all power tools at least monthly. Be sure you comply with the maintenance inspections of your command. Plan ahead. Use the prepared preventive maintenance schedule you received to help in job production and save the time lost to inspection.

As mentioned before, you are responsible for all tools assigned to you. The tool user is also responsible for tool safety and accountability. If you borrow a tool, be sure to return it to its proper place. Report any problems you have with tools. Remember tools are expensive. It also takes time to replace lost or broken tools.

TOOL SAFETY

Protect your hands from injury as directed by the applicable safety instructions whenever you use tools. You may be working under a severe handicap without the full use of both hands. Make it a habit to FOLLOW ALL SAFETY RULES.

TEN RULES OF TOOL SAFETY

Several important aspects of safety should remain uppermost in your mind when you are on the job. The ten rules are as follows:

- **LEARN** the safe way of doing your job before you start.
- **THINK** safety, and **ACT** safely at all times.
- Obey safety rules and regulations; they are for your protection.
- **WEAR** proper clothing and protective equipment.
- **CONDUCT** yourself properly at all times; horseplay is prohibited.
- **OPERATE** only the equipment you are authorized to use.
- **INSPECT** tools and equipment for safe condition before starting work;
- **ADVISE** your superior of any unsafe conditions or practices promptly.
- **REPORT** an injury to your superior immediately.
- **SUPPORT** your safety program and take an active part in safety meetings.

Additionally, there are several good tool habits to help you perform your work more efficiently and safely.

TOOL HABITS

“A place for everything and everything in its place” is just common sense. You cannot do an efficient, fast repair job when you have to stop and look around for each tool you need. The following rules will make your job easier:

KEEP EACH TOOL IN ITS PROPER STORAGE PLACE. A tool is useless when you cannot find it. When you return each tool to its proper place, you know where it is the next time you need it.

KEEP YOUR TOOLS IN GOOD CONDITION. Protect them from rust, nicks, cracks, burrs, and breakage.

KEEP YOUR TOOL ALLOWANCE COMPLETE. When you are issued a toolbox, each tool should be placed in it when the tool is not in actual use. When possible, the toolbox should be locked and stored in a designated area.

NOTE

Never leave your toolbox or individual tools adrift where they could become a missile, fallen object, or tripping hazard and cause injury to personnel nearby. To keep track of your tools, the NCF tool kits contain inventory sheets. When you receive a kit that does not contain an inventory sheet, request a sheet from CTR. Figure 3-1 shows a partial inventory listing of a plumber's kit.

USE EACH TOOL ONLY ON THE JOB FOR WHICH IT WAS DESIGNED. When you use the wrong tool to make an adjustment, the end result will probably be unsatisfactory. For example, if you use a socket wrench that is a trifle too big, you will round off the corners of the wrench or nut. If this rounded wrench or nut is not replaced immediately, the safety of your equipment may be jeopardized in an emergency.

KEEP YOUR TOOLS WITHIN EASY REACH AND WHERE THEY CANNOT FALL ON THE FLOOR OR INTO MACHINERY. Avoid placing tools anywhere above machinery or electrical apparatus. Serious damage can result when a tool falls into the machinery after the equipment is energized.

NEVER USE DAMAGED TOOLS. A battered screwdriver may slip and spoil the screw slot, damage other parts, or cause painful injury. A gauge strained out of shape can result in inaccurate measurements.

Remember, the efficiency of a craftsman is determined to a great extent by the condition of his or her tools and the manner in which they are maintained. Anyone watching a skilled craftsman at work notices the care and precision with which tools of the trade are being used.

The care of hand tools should follow a pattern similar to personal articles; that is, always keep hand tools clean and free of dirt, grease, and other foreign matter. After use, return the tools promptly to their proper place in the toolbox. Improve your efficiency by organizing tools in such a way that those used most frequently can be reached easily without digging through the entire contents of the toolbox. Avoid accumulating unnecessary junk.

Q1. You should always use tools safely and in what manner?

Q2. Tool kits available in an NMCB are listed in what NCF inventory?

UNDERGROUND SANITARY PIPING

LEARNING OBJECTIVE: *Recognize the different types of piping and methods for measuring, cutting, and joining sanitary piping.*

The main purpose of a sanitary sewage collection system is to transfer sewage from the source to the sewage treatment plant. Raw sewage that is not transferred safely to a sewage treatment plant can harm human beings because it contains harmful bacteria.

The sanitary sewage collection system includes all house sewers, laterals, branches, interceptors, force mains, and so on. In this section of the chapter, we are primarily concerned with materials and operations required in the installation of sewer systems.

The installation of an underground sewer system for transferring domestic sewage from the source to the sewage treatment plant includes (1) trenching and grading, (2) measuring and cutting pipe, (3) laying pipe, (4) joining pipe, (5) testing, and (6) backfilling and tamping.

TRENCHING AND GRADING

Underground pipe requires excavation, either manually or with heavy equipment, depending primarily on the size of the job and the type of soil to be removed. On a large job where the soil is suitable for machine work, your project supervisor arranges to have Equipment Operators operate those pieces of equipment necessary to excavate or dig the trench. When it is impractical to use machines, you must do the job with a pick and shovel. Whichever method is used, the trench must be dug wide enough (2 feet minimum) to allow ample working room to join pipe sections. The bottom of the trench must also be sloped in the direction of flow, so sewage traveling through the pipeline laid in the trench is not restricted. On most jobs, an Engineering Aid is on hand to check elevations to ensure that the slope of the trench is close to the slope where the pipe is to be laid. On most jobs, Engineering Aids establish a system of batter boards and grade bars (explained later) for you to check the slope of the pipeline accurately, as it is being laid in the trench. Check the job specifications for the proper grade of the sewer line being installed. When specifications are not available, a rule of thumb is to

FACSO RPT SYM/NO. 0440/B3561R0		INVENTORY MANAGEMENTS SYSTEMS										92MAR02	
PROJECT NO. N0293		KIT INVENTORY LIST										PAGE 22	
SEQ. NO. 2		SEQUENCE = KIT, SEQ. NO., ALPHA											
		(JULIAN DATE OF INVENTORY/ NAVSUP FORM 1250 DEPT NO., AND QUANTITY SHORT)											
COG		STOCK NUMBER	QTY	UNIT	PRICE	EXT. PRICE	(J/D)	(J/D)	(J/D)	(J/D)	(J/D)	DEPT # (QTY)	DEPT # (QTY)
9Q	5136-00-555-8912	1 EA	471.17	471.17	471.17	471.17	()	()	()	()	()	()	()
THREADER, PIPE, HAND, ADJUSTABLE SEG													
MENTAL DIE, 1 TO 2 NPT													
9G	3439-01-068-2003	1 EA	175.47	175.47	175.47	175.47	()	()	()	()	()	()	()
TOUCH AND HANDLE, HEATING, FOR USE W/ALL													
LP GASES (USE WITH NSN 3939-01-067-9299)													
9G	3439-01-067-9299	1 EA	86.68	86.68	86.68	86.68	()	()	()	()	()	()	()
TOURCH OUTTIT SOLDERING AND HEATING													
FUSE W/ALL LP GASES W/HOSE, REGULATOR,													
HANDLE AND TWO TIPS (SEE SKO FOR													
COMPONENT BREAKDOWN)													
9Q	5120-01-204-9844	1 EA	175.47	175.47	175.47	175.47	()	()	()	()	()	()	()
VISE ABD STAND PIPE 1/4n -4n CHAIN 3 LEGS W/													
PIPE BENDER 45-12LBS													
9Q	5110-00-837-0990	6 EA	1.97	11.82	11.82	11.82	()	()	()	()	()	()	()
WHEEL PIPE CUTTING 3/4N BORE DIA 3/4N LX													
.08N MAX W X 1-17/64N OD CUTTING BLADE 58N OD													
HUB													
9Q	5120-00-277-9086	1 EA	48.15	48.15	48.15	48.15	()	()	()	()	()	()	()
WRENCH ADJ MONKEY 1-3/16N MAX 7-3/4N OAL													
NON-MAGNETIC NON-SPARKING													
9Q	5120-00-449-8083	2 EA	7.92	15.84	15.84	15.84	()	()	()	()	()	()	()
WRENCH ADJ OPEN END 1-1/8N MAX SGL HEAD													
RACK/WORM ADJ 12N OAL CHROME													
9Q	5120-00-264-3796	1 EA	10.71	10.71	10.71	10.71	()	()	()	()	()	()	()
WRENCH ADJ OPEN END 1-5/16N MAX SGL HEAD													
RACK/WORM ADJ 12N OAL CHROME													

Figure 3-1.—Plumber's kit inventory list.

slope the trench 1/4 inch per foot. This is the grade at which sewage flows freely through a pipe and provides proper scouring action to keep the sewage flowing.

When a pipeline is to be laid in stable soil, such as hard clay or shale, the trench should be excavated below the pipe grade. If bell-and-spigot pipe is to be used, excavation must be made for the bells. See that enough undisturbed earth remains at the bottom of the trench, so the pipe, both joints and hubs, rests on and is fully supported by undisturbed earth. In areas where the temperature drops below freezing, the trench must be excavated deep enough for the pipeline to be below the frost line. Pipes that cross under roads or areas of vehicular traffic must be buried in trenches at least 4 feet deep and may require some type of metallic sleeving. Refer to the specifications of the job for details on sleeving pipe.

The sides of excavations, 4 feet or more in depth or in which the soil is so unstable that it is not safe at greater depths, should be supported by substantial and adequate sheeting, sheetpiling, bracing, shoring, and so forth, or the sides should be sloped to the angle of repose. Surface areas adjacent to the sides should be well-drained. Trenches in partly saturated, filled, or unstable soils must be suitably braced.

SANITARY DRAINAGE PIPING

Among the pipe materials installed underground by Utilitiesmen are cast-iron soil pipe, vitrified clay pipe, concrete pipe, and plastic pipe.

Cast-Iron Soil Pipe (CISP)

Cast-iron soil pipe and fittings are composed of gray, cast iron that is made of compact, close-grained pig iron, scrap iron and steel, metallurgical coke, and limestone. Cast-iron soil pipe is used in and under buildings, protruding from 2 to 10 feet from the building. (The *National Standard Plumbing Code-Illustrated* recommends at least 3 feet.) Here it connects into a concrete, plastic, or clay house sewer line. Cast-iron soil pipe is also used under roads or other places of heavy traffic.

When the soil is unstable, it is better to use cast-iron soil pipe; however, cast-iron soil pipe should not be used in soil containing cinders or ashes; the reason is that the soil may contain sulfuric acids, which cause the pipe to corrode and to deteriorate rapidly.

NOTE

When the soil contains cinders and ashes, instead of using cast-iron soil pipe, use vitrified clay or plastic pipe.

The cast-iron soil pipe used in plumbing installations comes in 5-foot and 10-foot lengths. Sizes of cast-iron soil pipe are 2, 3, 4, 6, 8, 10, 12, and 15 inches nominal inside diameter. It is available as single hub or double hub in design, as shown in figure 3-2. Note that single-hub pipe has a hub at one end and a spigot at the other. The double-hub pipe has a hub at both ends. Hubs, or bells, of cast-iron soil pipe are enlarged sleeve-like fittings. They are cast as a part of the pipe and are used to make a water- and pressure-tight joint with oakum and lead. Cast-iron soil pipe is generally available in two weights: standard or service (SV) and extra heavy (XH). The extra heavy pipe is used where superior strength is required, for example, under roadways, where the pipe may vibrate or settle slightly, and tall stacks. Standard or service weight pipe is adequate for most Navy base construction.

MEASURING.—Cast-iron soil pipe sections are generally 5 and 10 feet in length, but strictly speaking, this is not true. The reference to a 5-foot length of pipe applies to the laying length, not the overall dimensions. For clarity, first note that cast-iron soil pipe in 2-, 3-, 4-, and 6-inch (inside) diameter sizes are in common use. The length of the bell for the 3-inch-diameter pipe is 2 3/4 inches; and for the 4- and 6-inch-diameter sizes, the length is 3 inches. Now note that while the laying length of a 4-inch-diameter

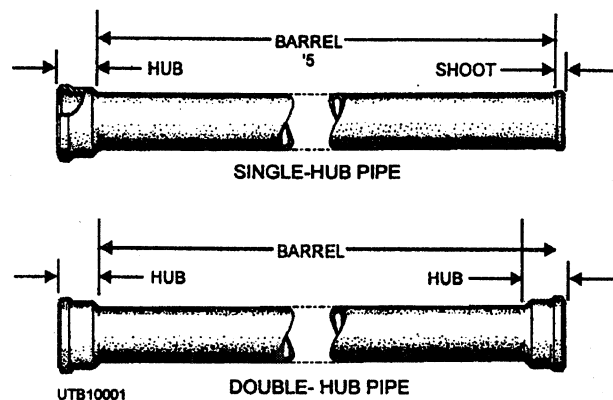


Figure 3-2.—Single-hub and double-hub cast-iron soil pipe.

cast-iron soil pipe is 5 feet, the overall length is 5 feet 3 inches.

The most common measurement of cast-iron soil pipe, for a shorter length than 5 feet, is the overall measurement. When making this measurement for 4-inch pipe, you should take the desired length of pipe for the installation and add 3 inches to it for the bell.

CUTTING.—Before joining cast-iron pipe, you often have to cut the pipe to provide the desired length. Cast-iron soil pipe can be cut with an abrasive cutter, a band saw, a hydraulic manual snap or ratchet cutter (fig. 3-3, views A and B), or a hammer and chisel. The hammer and chisel method is slow and used only when other cutting tools are not available. Here is a step-by-step procedure for cutting with a hammer and chisel.

- Mark or score the pipe with a triangular file or wrap your belt around the pipe and mark the cut line with soap stone.
- Lay the pipe over a board or mound of earth at the point to be cut to support the pipe (fig. 3-4) and allow it to turn easily.
- Score the pipe with a cold chisel (not too sharp). Move the chisel a little at a time along the mark, tapping lightly with a hammer until the pipe is evenly scored all around.

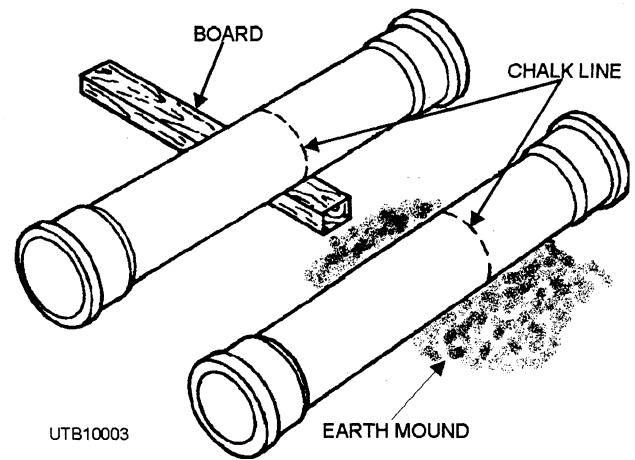


Figure 3-4.—Supporting soil pipe for cutting.

- Continue to turn the pipe and strike the chisel with increasingly heavier blows until the pipe breaks on the line evenly.

Another means of cutting a short piece, 1 or 2 inches, is with a hacksaw and an adjustable wrench. Cut a groove with the hacksaw around the pipe to a depth equal to one half of the wall thickness of the pipe. Break away the section of pipe with an adjustable wrench, used as a lever, as shown in figure 3-5.

A good point to remember is that if you must cut a short piece of CISP (cast-iron soil pipe), cut it from a piece of double-hub pipe (a hub on both ends instead

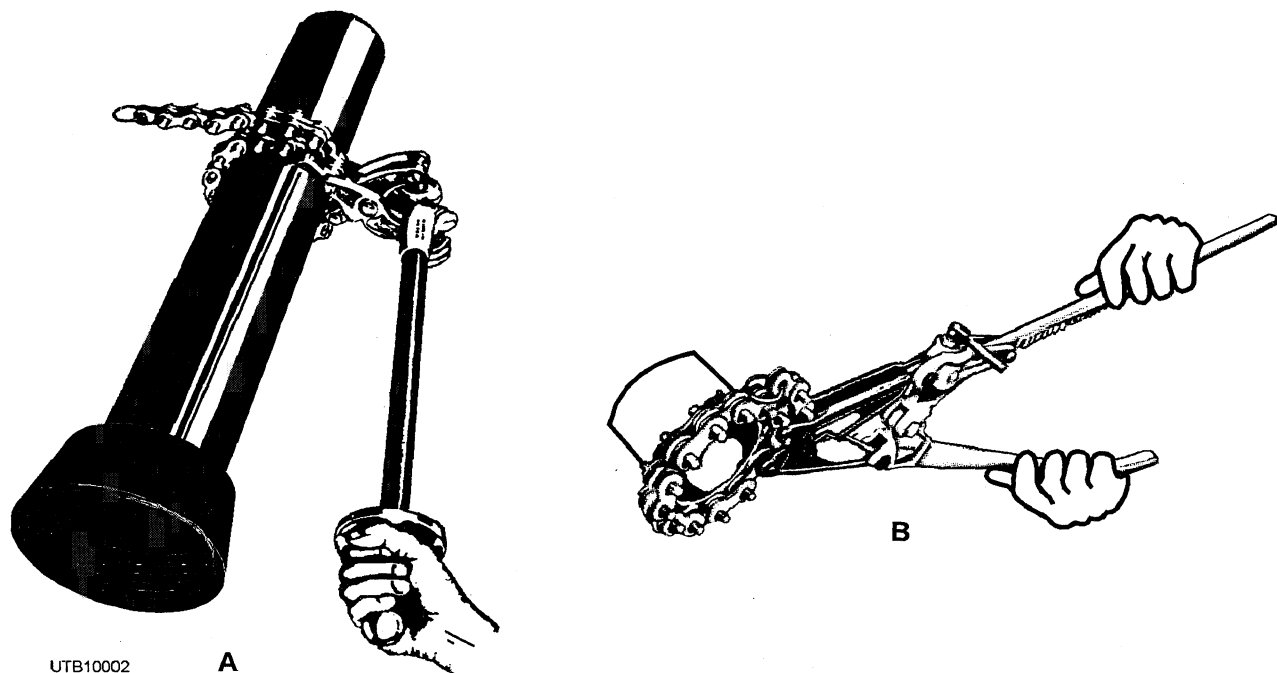


Figure 3-3.—Ratchet cutter and squeeze cutter.

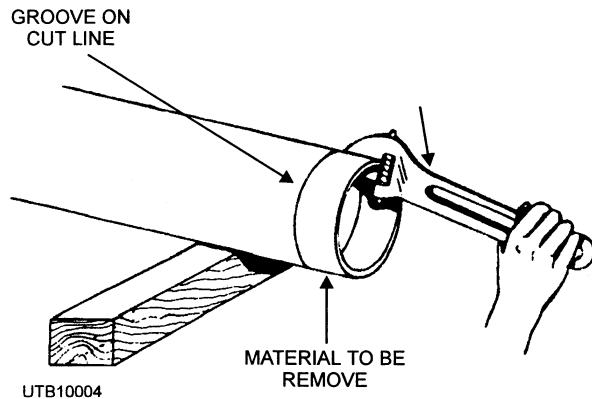


Figure 3-5.—Cutting cast-iron pipe with hacksaw and adjustable wrench.

of a hub and spigot). Thus the remaining pipe still has a hub, and it can be used.

FITTINGS.—Cast-iron soil pipe fittings are used for making branch connections or changes in the direction of a line. Both cast-iron soil pipe and fittings are brittle, so exercise care to avoid dropping them on a hard surface. Some of the cast-iron soil pipe fittings you may use in your work are described below.

A number of different types of bends are generally used on jobs involving cast-iron soil pipe. Some of the common types are the 1/16, 1/8, short sweep 1/4, long sweep 1/4, and reducing 1/4 bend. Look at figure 3-6 to get an idea of the shape and appearance of each of these types of bends.

The 1/16 bend is used to change the direction of a cast-iron soil pipeline 22 1/2 degrees. A 1/8 bend is

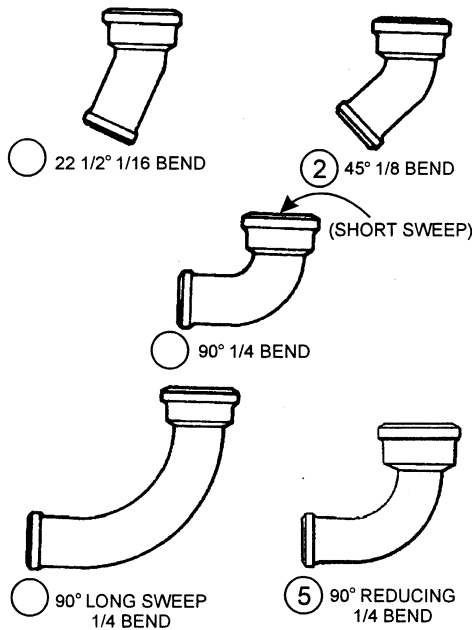


Figure 3-6.—Types of cast-iron soil pipe bends.

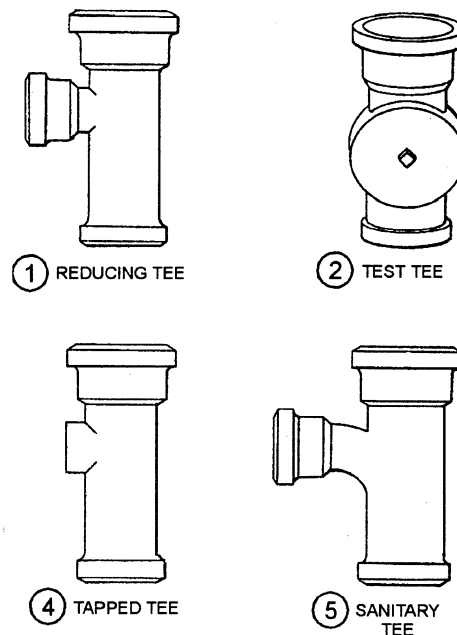
used to change the direction of a cast-iron soil pipeline 45 degrees. The SHORT SWEEP 1/4 bend is a fitting used to change the direction of a cast-iron soil pipeline 90 degrees in a short space. The LONG SWEEP 1/4 bend is used to change the direction of a cast-iron soil pipeline 90 degrees, but more gradually than the short sweep 1/4 bend. The REDUCING 1/4 bend gradually changes the direction of the pipe 90 degrees, and in the sweep portion, it reduces nearly one size. A 4 by 3 reducing long sweep 1/4 bend has a 4-inch SPIGOT on one end, reducing 90 degrees to a 3 1/4-inch HUB on the other end. Note that for all CISP fittings, the spigot end is always listed first.

Tees connect branches to continuous lines. Learn to recognize the four designs of tees shown in figure 3-7. For connecting lines of different sizes, REDUCING tees are often suitable.

The TEST tee is used in stack and waste installations where the vertical stack joins the horizontal sanitary sewer (fig. 3-8). It is installed at this point, so the plumber can insert a test plug and fill the system with water in testing for tightness. The test tee is also used in multistory construction.

The TAPPED tee is frequently used in the venting system; it is called the main vent tee. The SANITARY tee is commonly used in a main stack to allow the takeoff of a cast-iron soil pipe branch.

Four types of cast-iron soil pipe 90-degree Y-branches are in general use, as shown in view A,



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Figure 3-7.—Cast-iron soil pipe tees.

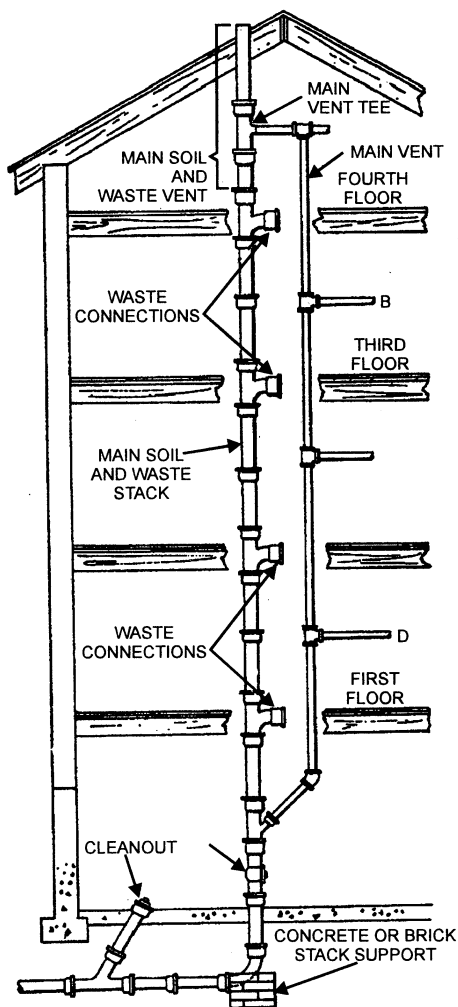


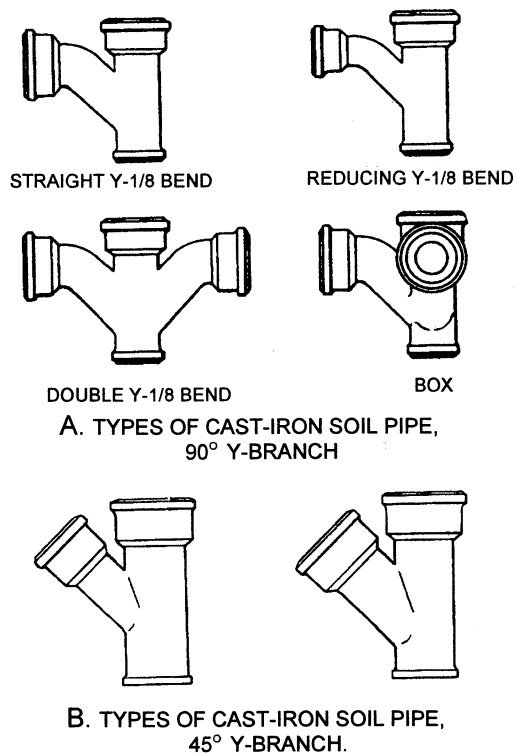
Figure 3-8.—Typical stack and vent installation.

figure 3-9. These are normally referred to as combination Y and 1/8 bends.

The STRAIGHT type of 90-degree Y-branch has one section that is straight through and a takeoff on one side. The side takeoff starts out as a 45-degree takeoff and bends into a 90-degree takeoff. This type of branch is used in sanitary sewer systems where a branch feeds into the main, and it is desirable for the incoming branch to feed into the main as nearly as possible in a line parallel to the main flow.

The REDUCING 90-degree Y-branch is similar to the straight type; however, as shown in view A, figure 3-9, the branch takeoff of the 90-degree Y-branch is smaller than the main straight-through portion. It is generally used the same as the straight type, except the branch coming into the main is a smaller pipe than the main.

The DOUBLE 90-degree Y-branch (or DOUBLE COMBINATION Y and 1/8 BEND) is easy to recognize since there is a 45-degree takeoff bending



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Figure 3-9.—Types of cast-iron soil pipe, 90- and 45-degree Y-branches.

into a 90-degree takeoff on both sides of the fitting, as shown in view A. It is very useful as an individual vent.

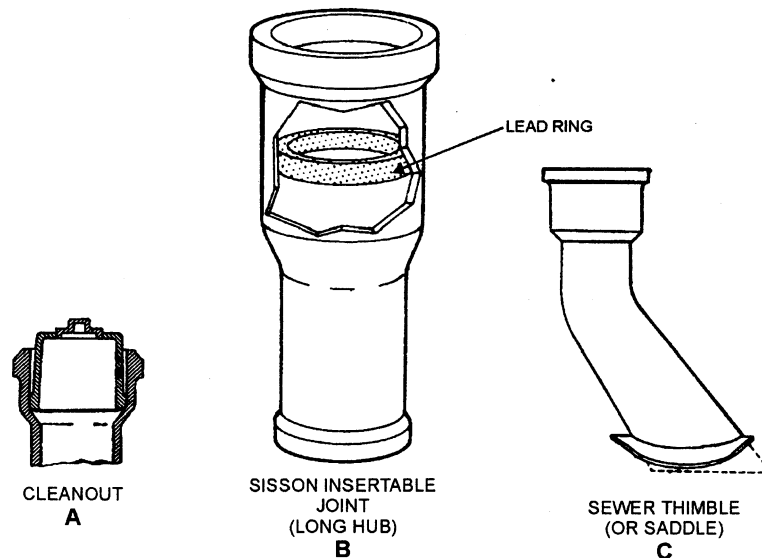
The BOX type of 90-degree Y-branch has two takeoffs. It is designed for each takeoff to form a 90-degree angle with the main pipe. The two takeoffs are spaced 90 degrees apart.

There are two types of cast-iron soil pipe 45-degree Y-branches. These are the reducing and the straight types; both are shown in view B, figure 3-9.

The REDUCING type is a straight section of pipe with a smaller size 45-degree takeoff branching to one side. There are different sizes of this fitting. As an example, a 4 by 4 by 3 reducing 45-degree Y-branch has a 4-inch-straight portion with a 3-inch 45-degree takeoff on one side.

The STRAIGHT type of 45-degree Y-branch, or true Y, is the same as the reducing type, except that both bells are the same size. It is used to join two sanitary sewer branches at a 45-degree angle.

Cleanout plugs are installed to permit removal of stoppages from waste lines. View A, figure 3-10, shows one type of cleanout plug. It consists of an iron ferrule caulked with the hub of a pipe or fitting. The top opening is taped and threaded, so a pipe plug can be screwed into it. Cleanouts should not be more than 50



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Figure 3-10.—Adapter-type cast-iron soil pipe fittings.

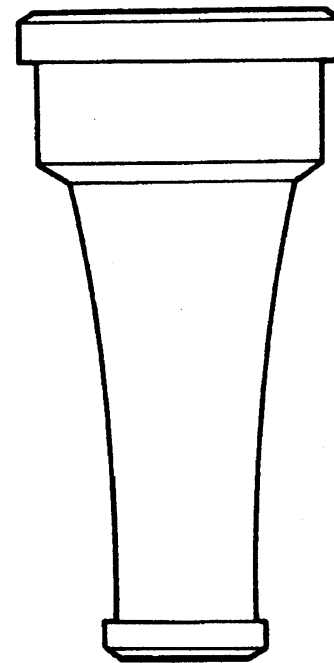
feet apart in horizontal 4-inch building drain lines in a straight run. When the change of direction is greater than 45 degrees (or a 1/8 bend), you must install a cleanout plug.

The long hub, or Sisson, type of cleanout (view B, fig. 3-10) is used as an insert to an existing line. The long hub allows you to push it up far enough to clear the other bell of the bottom pipe, and then to drop the fitting in place.

Another type of adapter is a sewer thimble (or saddle). This is a special fitting that is used to tie into an existing sewer line, as shown in view C, figure 3-10. It has a hub on one end, bending around to almost 45 degrees, with a flange near the opposite end. To install, cut a hole halfway between the top and the center line in the sewer line. The hole should be the same size as the outlet portion of the thimble beyond the flange. Slip the thimble into the opening until the flange seats on the sewer pipe. Using oakum and concrete, grout around the thimble to make a watertight joint.

The increaser (fig. 3-11) is used to increase the size (diameter) of a straight-through line. It is often used at the top of a main stack and vent.

A closet bend (fig. 3-12) is a special fitting inserted into a soil branch. This enables the soil branch to be fitted to the water closet. It may be untapped or have either one or two side taps for waste to vent use. Closet bends are made in different styles to fit different types of floor flanges (rims for attachment). One type (view A, fig. 3-12) has a spigot end for caulking into the branch line, and a scored end (marked with lines) to fit



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Figure 3-11.—Increaser.

into the floor flange. The scoring makes it easier to cut the bend to the desired length for a given connection. Another type, shown in view B, figure 3-12, has a hub connected to the floor flange with a sleeve or short length of pipe. The end caulked into the soil line is scored for cutting to size. Still other types may be scored for cutting at both ends or may be of the regular hub-and-spigot pattern.

Regular offsets, view A, and 1/8 bend offset, view B, figure 3-13, are used to carry the soil or waste lines

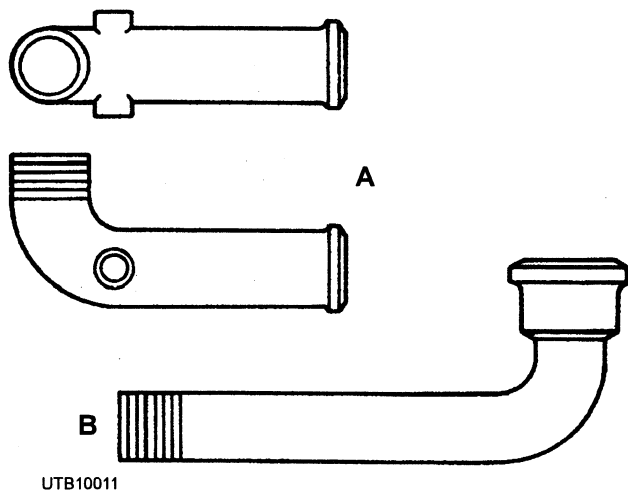


Figure 3-12.—Cast-iron soil pipe closet bends.

past an obstruction, such as a part of the building. The 1/8 bend offset gives a smoother transition than the regular one. Fittings for no-hub cast-iron pipe are identical to the others, except there are no hubs.

JOINING.—Various methods are used in joining pipe. This means that you must know the procedure to make various types of joints required for the kind of pipe to be joined. Lead and oakum joints, oakum and lead-wool joints, compression joints, and no-hub joints are means for connecting pipes. Figure 3-14 shows these types of joints; however, if oakum is not available, cotton braid or jute can be used as a substitute. Oakum is made of hemp or jute fibers, impregnated with a bituminous compound and loosely twisted or spun into rope or yarn.

In making caulked joints, you need various types of equipment. Because of the importance of this equipment, the common types of caulking equipment and safety procedures to be observed when making caulked joints are discussed.

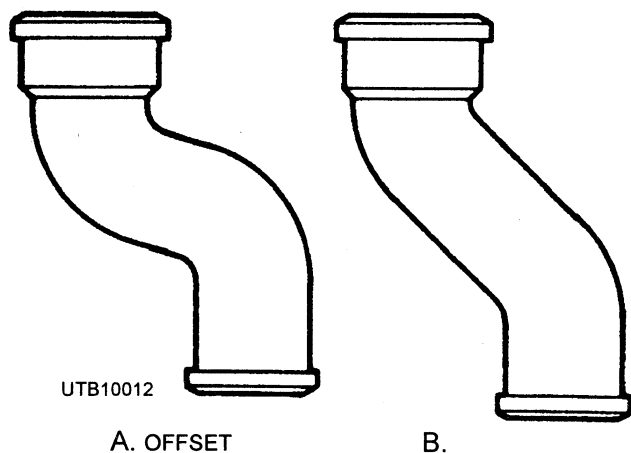
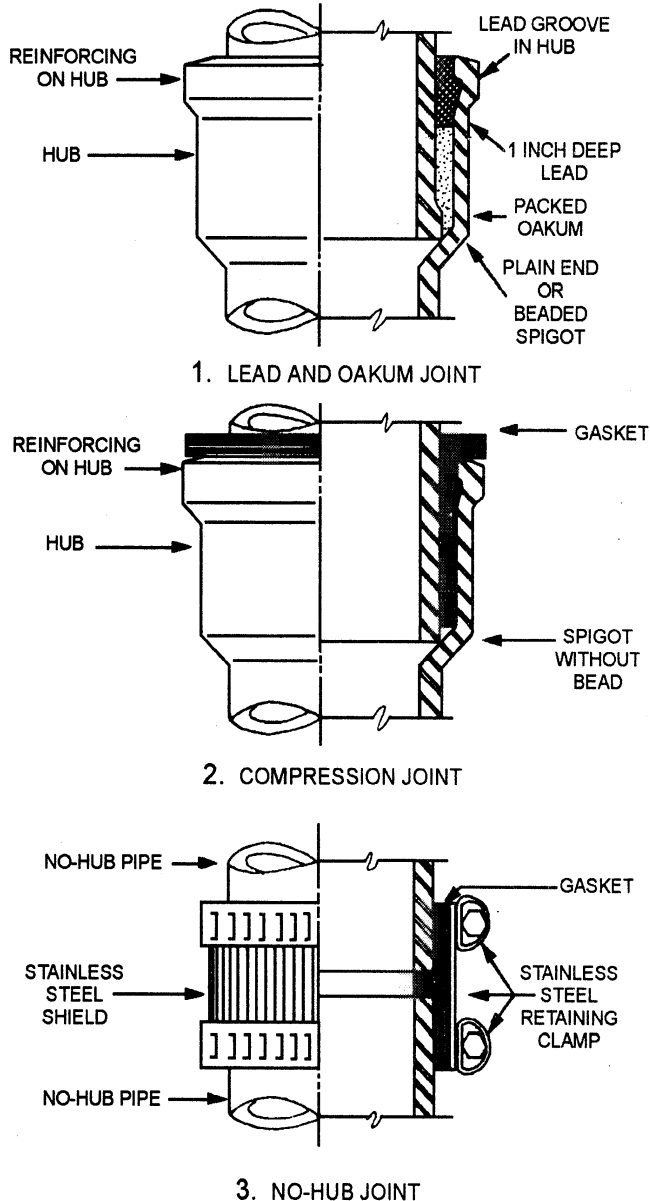


Figure 3-13.—Offsets.

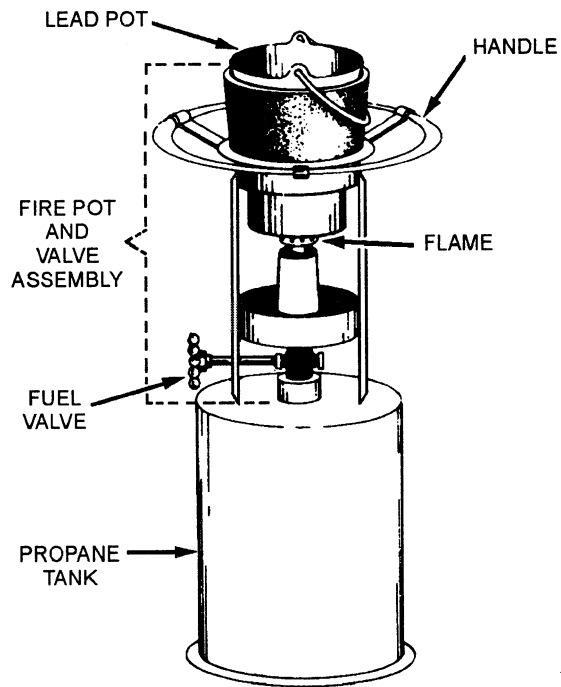


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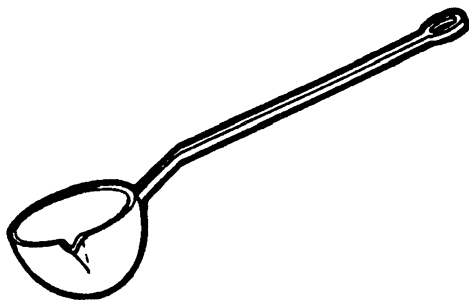
Figure 3-14.—Various joints used to connect CISP and fittings.

Equipment frequently used in making caulked joints in cast-iron soil pipe includes the melting furnace, melting pot, and plumber's ladle. These components are shown in figure 3-15. The melting furnace is a portable gas-burning furnace used to melt lead. The melting pot is made of cast iron and contains the lead while it is being melted on the furnace. The ladle, also made of cast iron, is used to spoon up the molten lead and carry it to the joint to be poured.

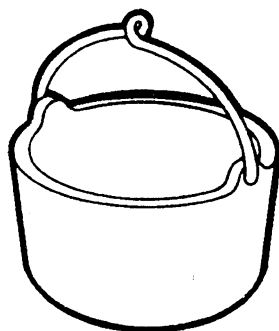
Several types of melting furnaces are available. Follow the manufacturer's instructions when you are operating a particular type. The general procedure below is for operating a MAPP-gas burning melting furnace.



1. PROPANE MELTING FURNACE



2. PLUMBER'S LADLE



3. MELTING POT

UTB10014

Figure 3-15.—Melting furnace, plumber's ladle, and melting pot.

This type of furnace consists of a fire pot and valve assembly that mounts directly on a portable propane gas tank. The tank is detachable and can be recharged with fuel. A propane furnace, as shown in figure 3-15,

lights instantly and burns with a high-temperature blue flame.

Look for leaks before you light the furnace. There is always a danger of explosion from gas leakage around the connections and valves. To light the propane furnace, fold or twist a piece of paper and light it. Hold the flame up and under the burner orifice of the fire pot. Stand back as far as possible and open the fuel valve until the burner lights. When the valve is opened too much or too rapidly, the pressure of the escaping gas may extinguish the lighter flame. If this should happen, close the fuel valve immediately and then light the paper before you reopen the valve.

Molten lead is dangerous. Most accidents occur because the Utilitiesman ignored safety procedures. When molten lead is handled, be **SAFETY MINDED**. When moisture gets into the molten lead, the heat will cause the moisture to boil rapidly and splash hot lead out of the melting pot. If you suspect moisture in the lead, heat the lead with a torch until the moisture is driven off. Now, you can add the lead to the melting pot. Make sure the plumber's ladle is free of moisture too.

When lead is melted, certain products of oxidation, known as slag, form on top of the molten metal. The slag must be removed from the lead before it can be used for pouring a joint. Scoop it up in the plumber's ladle. Use care in disposing of the slag.

Always preheat the ladle before you dip it into the lead because a cold ladle chills and solidifies some metals. When the ladle is in steady use, keep it hot by hanging it over the edge of the pot. In loading the ladle, use the bottom of it to push back the dross (or scum) on top of the lead, exposing enough clean lead so that the ladle can be filled and withdrawn without dross. Do not disturb the molten lead more than is necessary.

Wear a face shield, gloves, and protective clothing when melting and pouring the lead. Keep out of range of flying lead even though the joint appears dry. Also, see that drops of perspiration do not drop into the pot of hot lead.

When making vertical caulked joints, you should wipe the hub-and-spigot ends of the pipes to remove moisture and foreign matter. **WATER CAUSES MELTED LEAD TO SPATTER AND SERIOUS BURNS MAY RESULT**. If the ends are wet, dry them with a torch. Slide the spigot end of one pipe into the hub of the other and align the joint, so the cut end is in

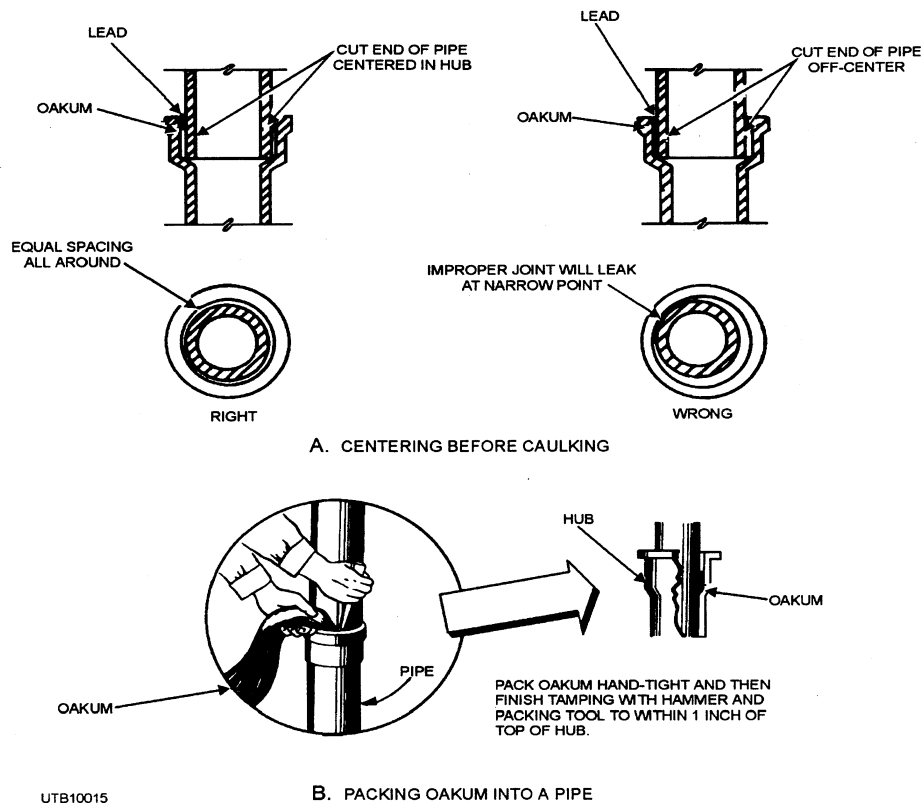


Figure 3-16.—Caulking cast-iron joints.

the center of the hub, as shown in view A, figure 3-16. As shown in view B, figure 3-16, use packing (yarning) irons (1 and 2, fig. 3-17), and pack a layer of spun or twisted oakum into the hub completely around the joint. Repeat with more layers until the hub is packed to about 1 inch from the top. Compress the oakum thoroughly to make a solid bed for the lead and to prevent leakage of the joint. With a plumber's ladle (2, fig. 3-15), pour melted lead carefully into the joint until it rises slightly above the top rim of the hub (fig. 3-18). Dip up enough lead with the ladle to make the joint in one pouring. Allow a minute or two for the lead to harden.

CAUTION

To avoid using a wet ladle to dip the hot lead, you must heat the ladle. Remember, moisture causes hot lead to spatter out of the melting pot. Always wear protective clothing, face shield, and gloves when working with hot lead.

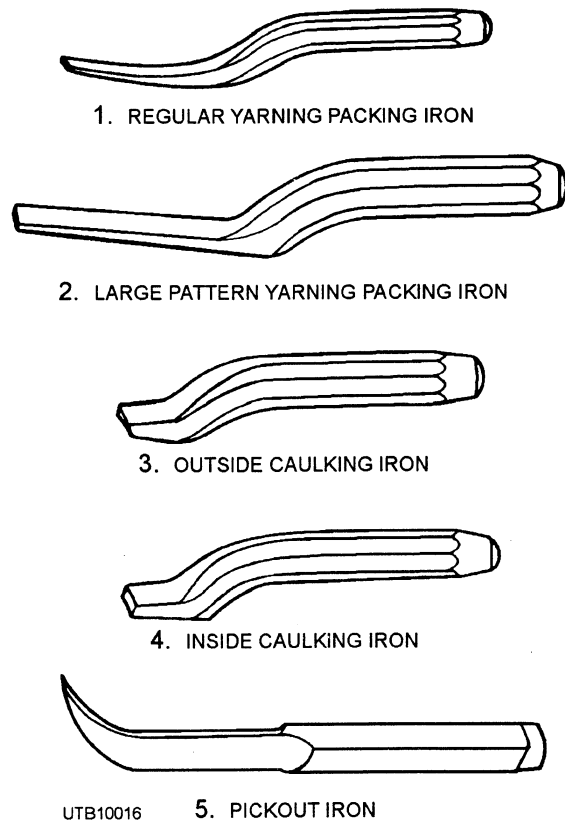
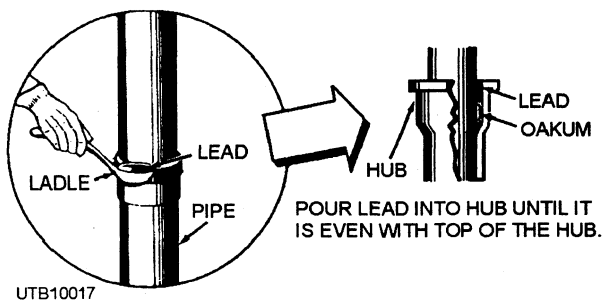


Figure 3-17.—Packing and caulking irons.



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Figure 3-18—Pouring hot lead into a joint.

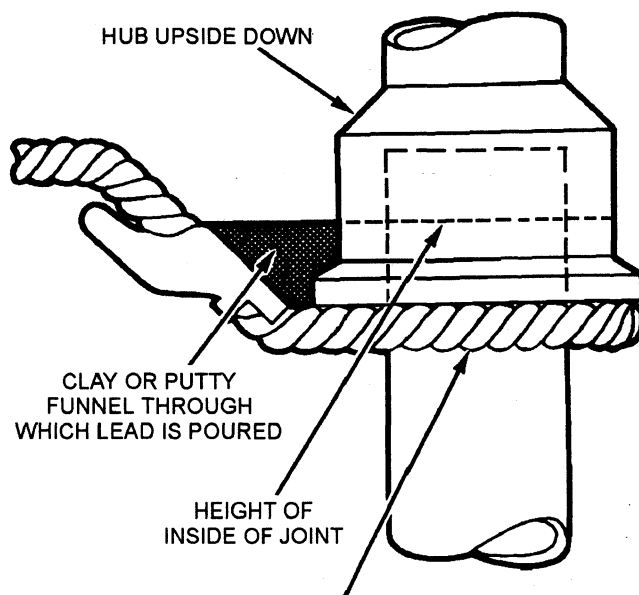
Perform caulking operations using an inside caulking iron first and then an outside caulking iron (views 4 and 3, fig. 3-17). Drive the lead down upon the oakum and into contact with the spigot surface on one edge and against the inner surface of the hub on the other. Strike the caulking iron gently but firmly with a hammer. Caulking the lead too tightly can crack the pipe. A cracked pipe or fitting must be replaced. A pickout iron (view 5, fig. 3-17) should be used when oakum and lead must be removed from a joint.

Sometimes a joint must be made in a vertical line with the hub upside down as in a vent stack. Prepare the ends of the pipes and pack the joint with oakum, as shown in view B, figure 3-16. Clamp a joint runner around the pipe. Raise the end of the joint runner, as shown in figure 3-19, and make a funnel in the raised end, using fine clay, putty, or plaster. The funnel must be at least as high as the inside height of the lead portion of the joint.

CAUTION

Be sure the funnel is dry before the lead is poured to prevent the hot lead from blowing out. Pour the lead and allow it to cool before removing the joint runner. Caulk the lead with a caulking iron to adjust it to the inside walls of the hubs.

When making a horizontal caulked joint, you must prepare the ends of the pipes by packing the joint with oakum, as shown in view A, figure 3-20. Clamp a joint runner around the pipe; place a small piece of oakum between the clamp and the pipe to seal the gap and prevent hot lead from running out of the joint; and then fill the joint with melted lead, as shown in view B, figure 3-20. After the lead hardens, remove the runner and the trim off of the surplus lead with a chisel. Caulk the lead in the same way as a vertical joint, as shown in view C, figure 3-20.



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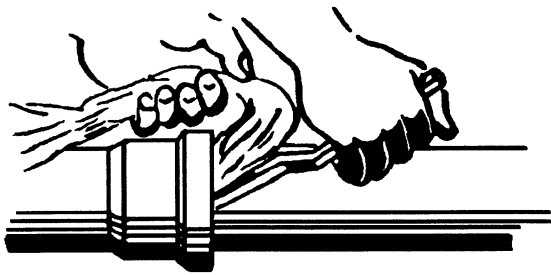
Figure 3-19.—Making an upside-down joint.

When making a lead-wool joint in cast-iron soil pipe, you need a yarning iron and a caulking iron. This is a cold-caulked joint and should be used where a line is underwater or in a wet place where molten lead cannot be used. Before starting the joint, place the spigot end of the pipe to be installed in the hub of the soil pipe. Make sure the pipe is blocked securely with braces to prevent shifting. The pipe must also be centered in the hub, so the thickness of the joint is uniform. With the pipe braced firmly and in proper position for joining, make the joint following the procedure provided below:

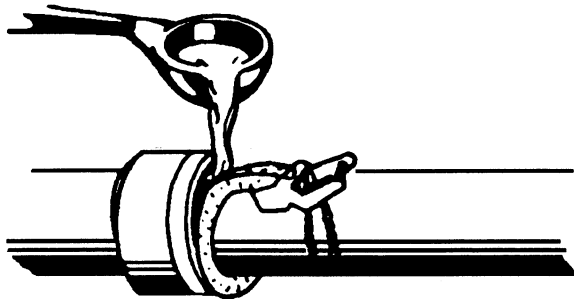
- Pack oakum in the joint to within 1 inch of the top of the hub. Use a ball peen hammer and a packing iron to tamp the oakum tightly in the joint.
- Pack two 1/2-inch layers of lead wool over the oakum.

Tamp the lead wool tightly into the joint, using the caulking irons and the ball peen hammer. (See fig. 3-21.)

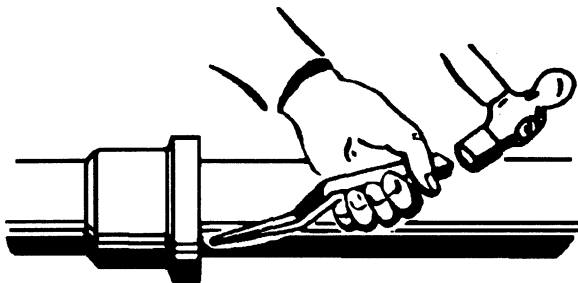
In making a compression joint, you should be sure to clean the internal surface of the hub and the external surface of the pipe and/or fitting to be joined. When using a cut pipe, you can remove the sharp edge by peening or by lightly filing the rough edge to permit the pipe to slide and NOT gouge into the gasket. Insert the gasket into the hub, and make sure the retaining flange or collar of the gasket is next to the face of the hub. Be sure to use the recommended lubricants available (normally a soap or an adhesive type). They are applied to the inside of the gasket. Align the spigot



A. PACK JOINT HALF FULL OF OAKUM.



B. CLAMP JOINT RUNNER AROUND PIPE AND POUR LEAD INTO JOINT. PLACE PUTTY OR CLAY ON BACKSIDE OF RUNNER TO PREVENT LEAD FROM RUNNING UNDER RUNNER CLAMP.



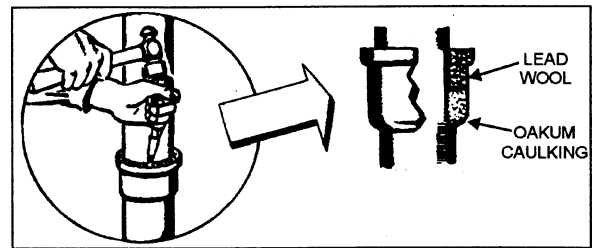
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C. REMOVE JOINT RUNNER WHEN LEAD HAS COOLED AND CAULK JOINT.

Figure 3-20.—Making a joint on horizontal piping.

and hub to be joined, keeping the spigot and hub in a straight line. The spigot end of the pipe or fitting can be forced into the gasket by using an assembly tool, as shown in figure 3-22.

When joining CISP as a no-hub joint, place a neoprene or an elastomeric gasket on the end of one pipe and the stainless steel shield and clamp assembly, as shown in figure 3-23, on the end of the other pipe. Firmly seat the pipe ends against the integrally molded shoulder inside the gasket. Slide the shield and clamps into position over the gasket and tighten the stainless steel clamps alternately and firmly to about 60 inch-pounds of torque. A torque wrench set at 60 inch-pounds is available in the NMCB cast-iron kit (assembly 80055).



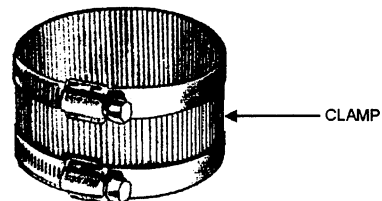
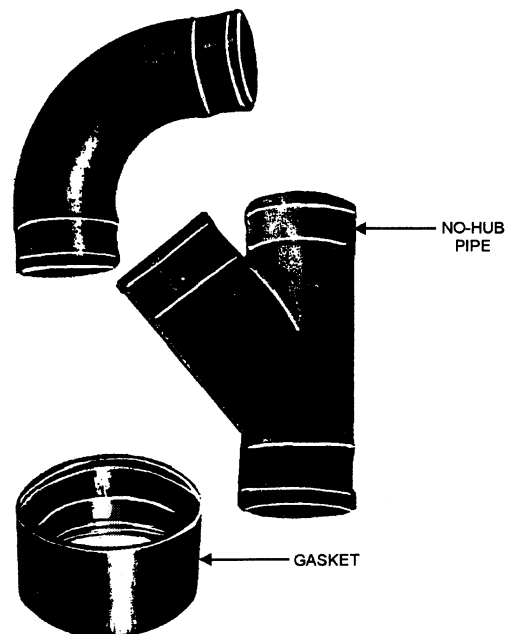
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Figure 3-21.—Tamping lead wool.



UTB10021

Figure 3-22.—Compression joint assembly.



UTB10022

Figure 3-23.—No-hub pipe and fittings.

Vitrified Clay and Concrete Pipe

Vitrified clay pipe is made of moistened powdered clay. It is available in laying lengths of 2, 2 1/2, and 3 feet and in diameters ranging from 4 to 42 inches. Like cast-iron soil pipe, it has a bell end and a spigot end to make joining easy.

After the pipe is taken from the casting, it is glazed and fired in large kilns to create a moistureproof baked finish. It is used for house sewer lines, sanitary sewer mains, and storm drains. The types of fittings for clay pipe are primarily bends, tees, and Y-branches.

You may have to use plain precast concrete pipe for sewers in the smaller sizes—less than 24 inches. This pipe is not reinforced with steel. This concrete pipe is similar to vitrified clay pipe in measuring, cutting, joining, and handling.

HANDLING AND STORAGE OF CLAY PIPE.—Be careful when you store and handle clay pipe because it is very fragile and cracks easily. Never drop clay pipe or roll it down an embankment without control. Do not drop heavy objects on clay pipe. When backfilling a trench, do not use fill with rocks or other heavy debris in it. Tamp by hand or by pneumatic tampers, bearing in mind the density of the backfill. Clay pipe should be laid in a trench and bedded evenly and firmly. The more perfect the bedding, the greater the load the pipe can sustain. Common sense can save a lot of time by eliminating rework.

CUTTING.—Vitrified clay and concrete pipe, both available in such short lengths, seldom need cutting except for manholes and inlets. If, after measurement, you have to cut vitrified clay or concrete pipe, score it with a chisel, deepening the cut gradually until the pipe breaks cleanly at the desired point. Vitrified clay and concrete pipes may be cut with CISP “snap-off” or “chain” cutters.

FITTINGS.—Figure 3-24 shows some common fittings used with vitrified clay and concrete pipes. Note that these types of pipes are used outside the building. This greatly reduces the number of different types of fittings required.

JOINING.—Joints on vitrified clay and concrete pipe may be made of cement or bituminous compounds. Cement joints may be made of grout, which is a mixture of cement, sand, and water. The following procedure may be used as a guide in joining pipe with grout. This procedure is very similar for joining pipe with bituminous compounds.

- Insert the spigot of one length of pipe into the bell of the other and align the two pieces to the desired position.
- Caulk a gasket of oakum about 3/4-inch thick into the bell to prevent the grout from running into the pipe.

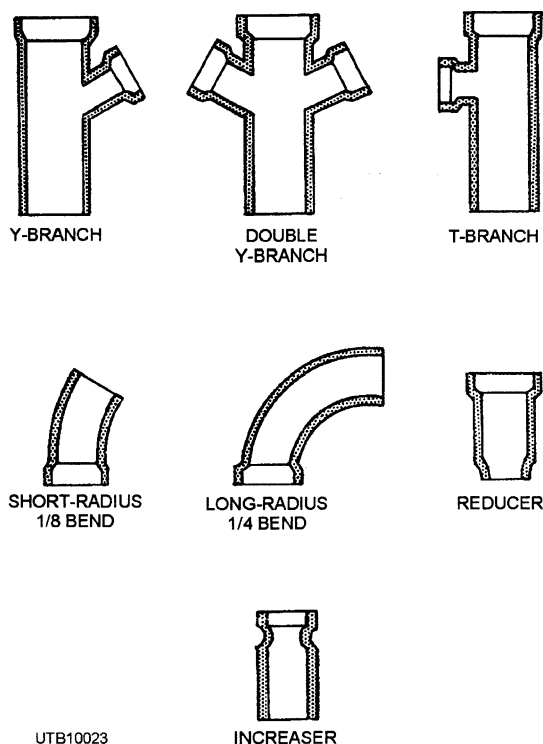


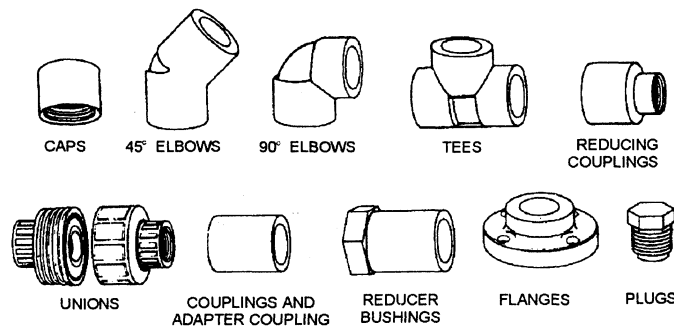
Figure 3-24.—Gross section of clay or concrete fittings.

- Mix grout, using 1 part portland cement, 2 parts clean, sharp, washed sand, and sufficient water to dampen thoroughly.
- Fill the joint with grout, using a packing iron.
- Recaulk the joint after 30 minutes with a packing iron. You have to close shrinkage cracks that occur after the initial set of the grout.
- Smooth and bevel the grout off with a trowel. In hot weather, cover the joint with a wet burlap sack.
- Remove excess mortar with either a swab or a scraper.

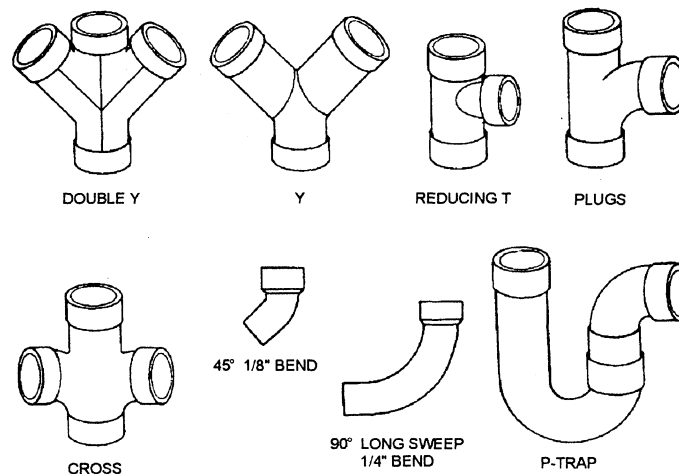
Note that a regular swab, with some additional rags tied to the end to compensate for larger size pipe, is ideal for dragging through each length to remove the excess mortar.

The use of “speed seal joints” (rubber rings) in joining vitrified clay pipe has become widespread. Speed seal joints eliminate the use of oakum and mortar joints for sewer mains. This speed seal is made a part of the vitrified pipe joint when manufactured. It is made of permanent polyvinyl chloride and called a “plastisol joint connection.” This type of joint helps to ensure tight joints that are rootproof, flexible, and so forth.

The speed seal, or mechanical seal, joint can be installed quickly and easily by one person. To make the joint, first insert the spigot end into the bell or hub.



PLASTIC PIPE FITTING



UTB10024

WASTE DRAINAGE FITTING
Figure 3-25.—Plastic pipe fittings.

Then give the pipe a strong push, so the spigot locks into the hub seal. A solution of liquid soap may be spread on the joint to help it slip into place easily. You will find that other types of mechanical seal joints are also available. They all use about the same method of installation. Special mechanical seal adapters are made to join vitrified clay pipe with CISP or CISP to vitrified clay pipe.

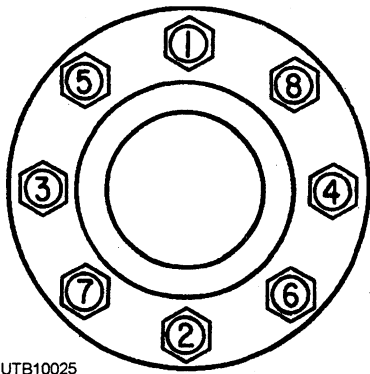
Plastic Pipe

At first, plastic was used for lawn sprinklers, farm water systems, and acid drainage from mines. Now plastic pipe is used for all kinds of applications, from shipboard installations to municipal water treatment and domestic water uses.

The advantages of plastic pipe (PVC—Polyvinylchloride) include resistance to nearly all acids, caustics, salt solutions, and other corrosive liquids. It does not scale, pit, corrode, or rust. Bacteria does not grow well, and it is also nontoxic. Plastic pipe has very low-friction resistance because of its smooth, inner surface. Being nonconductive, it is not subject to electrolytic corrosion. Plastic pipe can be used

underground in acid, alkaline, wet, or dry soil without a protective coating. It is strong and can handle operating pressures in most moderate service processes within the temperature range of that particular material. Plastic pipe is light in comparison to metal. Finally, it can be easily joined in a wide variety of methods. Each method has a certain advantage.

HANDLING AND STORING OF PLASTIC PIPE.—When unloading plastic pipe, do not drop it on the ground. Remember, scratches and gouges from dragging it on rough surfaces tend to reduce the pressure-carrying capacity. Pipe should be stored on racks to prevent sagging. Burrs and sharp edges on storage racks should be removed before storing the pipe. Plastic pipe should be stored in a shaded area away from any source of heat that could cause damage to the pipe. During prolonged storage, it should not be stacked more than 2 feet high because the weight causes it to flatten or go out of round. Before installing plastic pipe, inspect all pipe and fittings for cuts, scratches, buckling, and kinks that should be cut out.



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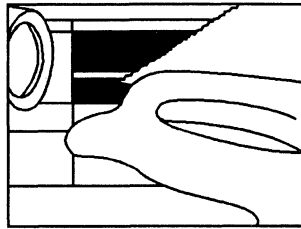
Figure 3-26.—Diametric order of tightening flange bolts.

CUTTING.—When cutting plastic pipe, use either a fine-toothed hacksaw, circular saw, band saw, or reciprocating saw with carbide-tipped blades. Pipe and tube cutters can be used when adapted with a deeper cutting blade made for cutting plastic pipe. **DO NOT USE** a tubing cutter. The cutting wheel will not cut deep enough, and the outside diameter (OD) of the pipe will become larger. Use a miter box or hold-down rig to help cut the pipe square. Remove all burrs and chips from both the inside diameter (ID) and outside diameter (OD) of the pipe. The end of the pipe should be beveled to approximately 1/16 inch to 3/32 inch at a

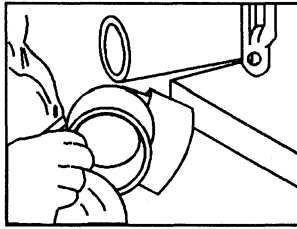
10-degree to 15-degree angle. This minimizes the wiping of solvent from the ID of the fitting, as the pipe is put into the socket. You can bevel the end of the pipe with a coarse file or special beveling tool.

FITTINGS.—Plastic flanges and flange fittings (fig. 3-25) are available in a full range of sizes and may be attached to the pipe. Soft rubber gaskets are preferred with plastic flanges. When tightening flange bolts, pull them down gradually to a uniform tightness and in a diametric manner, as shown in figure 3-26.

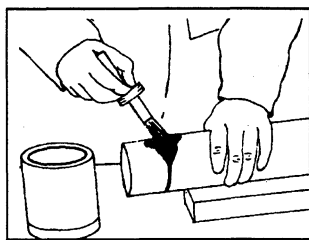
JOINING.—There are four methods of joining plastic pipe: solvent welding, fusion welding, fillet welding, and threading. Before solvent welding PVC and CPVC plastic pipe, clean the pipe and fittings, as shown in view B, figure 3-27. Use a clean, dry cloth and wipe away all loose dirt and moisture from inside the fitting and from the outside of the plastic pipe. Ensure the fittings and the pipe are of the same temperature for at least an hour before welding; this will assure they are thermally balanced. With a bristle brush, apply a coating of primer to the outside of the pipe. This removes surface gloss and etches the pipe.



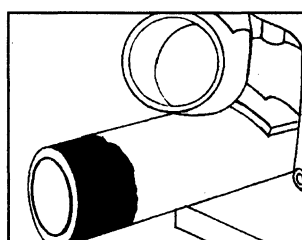
A. HOLD-DOWN RIG FOR CUTTING



B. CLEANING WITH DRY CLOTH



C. APPLYING CEMENT



D. JOINING

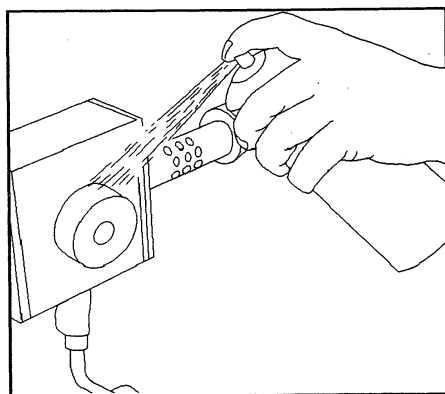
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Figure 3-27.—Making cement solvent weld joints on plastic pipe.

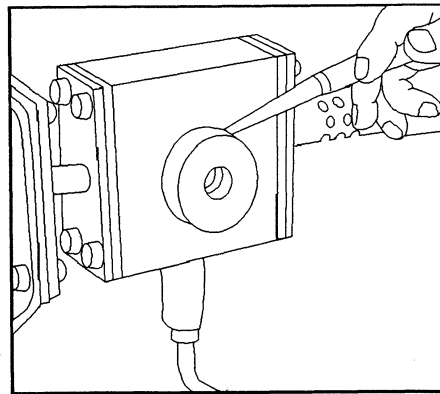
Do the same to the inside of the fittings. If the pipe is so hot the primer evaporates or if the pipe is above 90°F, move it to a shaded area before priming the surfaces. Use notched boards to keep the pipe ends out of the dirt. Clean the pipe ends before cement application.

Dip a brush in cement and apply it to the entire active surface of the pipe to a width slightly more than

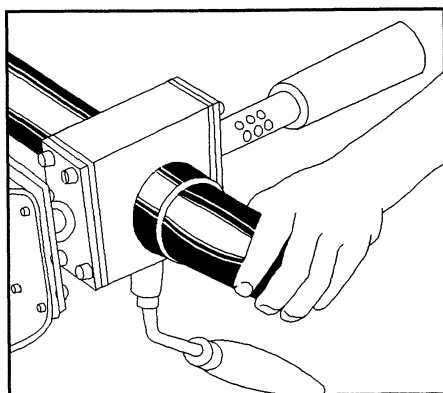
the depth of the socket of the fitting, as shown in view C, figure 3-27. Then brush a light coating in the depth of the socket. (Avoid excess cement to eliminate the buildup inside the fitting when the pipe is socketed.) Apply the second coating of cement to the end of the pipe to ensure no voids exist. (There should be no problem of too much cement on the pipe because the



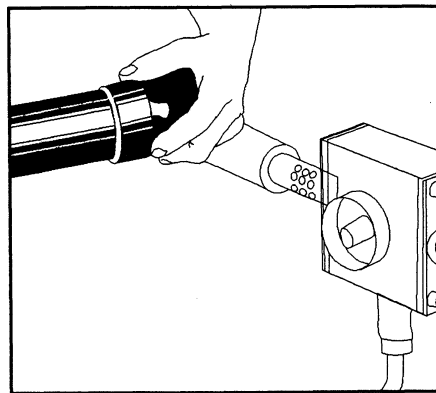
A



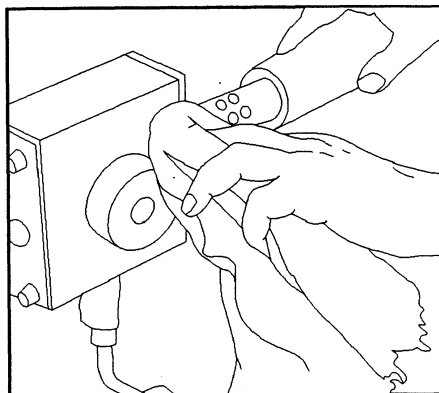
B



C



D



E

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Figure 3-28.—Fusion welding plastic pipe.

excess will bead out on the surface of the face of the fitting and can be easily wiped away.) Immediately, upon finishing the cement application, insert the pipe to full socket depth and rotate one fourth of a turn to ensure complete distribution of cement, as shown in view D, figure 3-27. Hold the pipe together for 10 to 15 seconds, so it does not move out of its socket. After joining, immediately wipe the excess cement from the pipe and fitting and gently set the pipe on a level surface. Do NOT move the pipe for about 2 minutes. (As the pipe size increases, it takes longer for the joint to set up.) The pipe **SHOULD NOT** be joined in temperatures below 40°F and above 90°F or when it is exposed to direct sunlight. The drying time should be at least 48 hours before the joint is moved or subjected to internal or external pressure. The drying time is shorter in hot weather and longer in colder weather. **DO NOT ATTEMPT TO SPEED THE SETTING OR DRYING OF THE CEMENT BY APPLYING HEAT TO SOLVENT-WELDED JOINTS.** Forced rapid drying by applying heat causes cement solvent to boil off, forming bubbles and blisters in the cement film. During cool weather, the setting of the cement can be speeded by prewarming the cement, the pipe, and the fitting, or by shielding the joint from the wind. **CHECK THE SHELF LIFE OF THE CEMENT.** Do NOT use cement that is lumpy or stringy. Do NOT try to thin it out with a thinner or primer. Always follow the instructions on the cement container; the above estimates should in no way be used in the place of application instructions.

Fusion welding requires either a gas- or an electric-heated welding tool, as shown in figure 3-28. As the tool warms up, spray its contact surfaces lightly with a silicone-releasing agent (view A, fig. 3-28). This prevents the pipe from sticking to the surface of the welding tool. Check the temperature of the tool. Ensure the tool reaches the proper temperature range (view B, fig. 3-28) before placing the pipe on the heating element. Be sure the pipe is squarely on the element. Hold onto the pipe, as shown in view C, figure 3-28, until a bead appears on the pipe at the entrance of the female tool piece. After the bead appears, remove the pipe and insert it into the fitting, squarely and completely, as shown in view D, figure 3-28. **DO NOT ROTATE THE PIPE WHILE IT IS BEING JOINED WITH THE FITTING.** After joining, clean the fusion welding tool, as shown in view E, figure 3-28.

In fillet welding plastic pipe, as shown in figure 3-29, maintain uniform heat and pressure on the rod while welding. Too much pressure on the rod stretches the bead and causes the weld to crack, as it cools. The

rod should be held at a 90-degree angle to the joint. The rod bends in an arc when proper pressure is applied. When finishing a weld, make the bead overlap the top, **NOT** alongside itself, for at least 3/8 to 1/2 inch. Never overlap alongside when welds are being spliced.

Threaded plastic pipe should be used only as a temporary piping system. Threading reduces the wall thickness and results in lower pressure ratings. Only schedule 80 or heavier pipe should be used when plastic pipe is being threaded. Never use pipe wrenches to tighten threaded pipe; use a strap wrench, as shown in view A, figure 3-30. Be sure to use an insert within the vise jaws to prevent scoring of the pipe. Use a wood or aluminum plug while the pipe is being threaded to prevent distortion of the pipe and to avoid off-center threads, as shown in view B, figure 3-30. The dies should be sharp; and for best results with power tools, use a 5-degree negative front rake. When tightening threaded joints, avoid too much torque. One or two turns past hand-tight is sufficient. Teflon tape should be used as a pipe joint compound.

PLACING PLASTIC PIPE IN THE GROUND.—On hot days, after the plastic pipe has been cement solvent welded, it is a good idea to snake the pipe beside the ditch or if the ditch is wide enough, in the ditch during its required drying time. **DO NOT APPLY STRESS or DISTURB A JOINT THAT IS DRYING.** Snaking gives added length to the pipeline to compensate for thermal contraction, as the pipe cools. When the temperature change is less than 30°F, snaking is not necessary. When cement solvent welding on a hot, summer day during the late afternoon, be sure to snake the line. Since the pipe

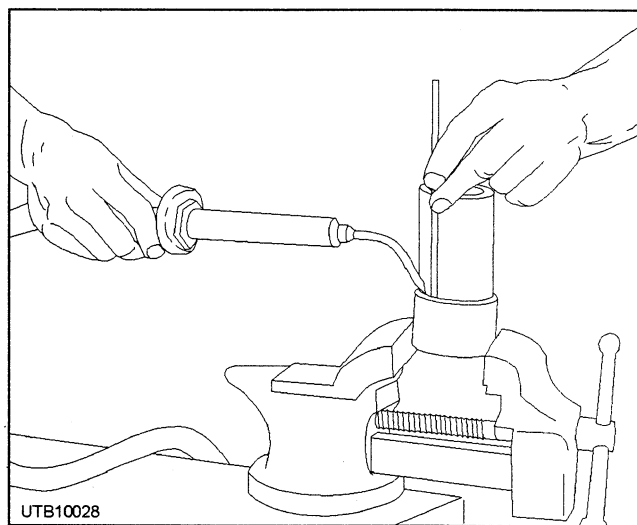
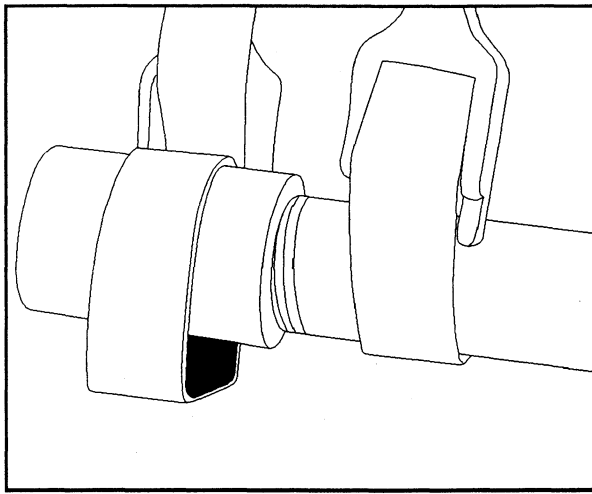
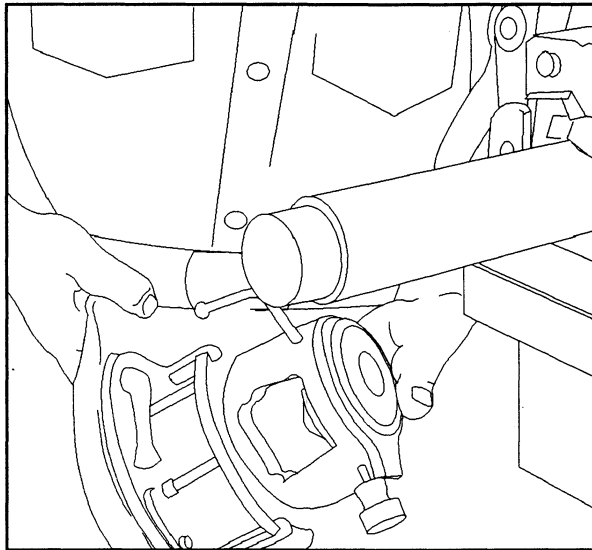


Figure 3-29.—Fillet welding plastic pipe.



A



B

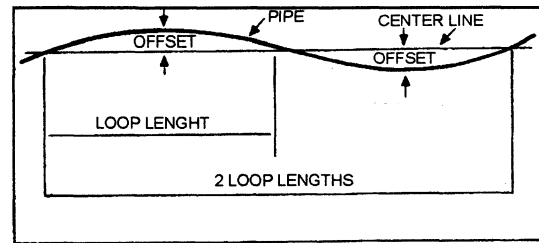
Figure 3-30.—Threading plastic pipe.

dries during the cool of the night, the thermal contraction of the pipe could stress the joint and pull the pipe apart due to the inadequate time to allow for the cement to cure. See table 3-1 for a general guideline on “loop” dimensions for various lengths of line and temperature ranges.

TESTING.—Testing should be done in two intervals:

1. The initial test should be a low-pressure hydrostatic test. (Air or gas is NOT recommended.) This test should never exceed 50 pounds per square inch gauge (psig). When testing with a gauge, allow the pipe to remain under pressure for a few hours; then check to see if there is a pressure drop. When the pressure drops, there is a leak. The pipeline should then be walked and closely inspected, checking each joint closely. After

Table 3-1.—Pipe Snaking Loop Offset
PIPE SNAKING



LOOP OFFSET IN INCHES FOR CONTRACTION

	MAX. TEMPERATURE VARIATION, F, BETWEEN TIME OF SOLVENT WELDING AND FINAL USE				
LOOP LENGTH	10°	20°	30°	40°	50°
20 Feet	3"	4"	5"	5"	6"
50 Feet	7"	9"	11"	13"	14"
100 Feet	13"	18"	22"	26"	29"
LOOP LENGTH	60°	70°	80°	90°	100°
20 Feet	6"	7"	7"	8"	8"
50 Feet	16"	17"	18"	19"	20"
100 Feet	32"	35"	37"	40"	42"

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locating the leak, repair it, and pressurize it again using LOW pressure.

2. After completion of the low-pressure test, place the pipeline in the trench (if not tested in the ditch) and backfill, leaving the joints exposed. The pipe should be uniformly and constantly supported its entire length. **DO NOT SUPPORT WITH BLOCKS.** The high-pressure test should be conducted at 1 1/2 times the working pressure and be held for at least 12 hours. Leaks found on the pipe itself should be cut out completely and replaced by using fittings (couplings). Backfill in the early morning during hot weather. The pipe should be covered 6 to 8 inches with backfill that is free of rocks and debris. It is advisable to maintain a pressure of 15 to 20 psig on the pipeline while backfilling to keep from damaging it. Anchors, valves, boxes, and so forth, should be supported separately to prevent additional stress or bending from the pipe. Piping, under roadways or railroads, should be done with sleeving (metal or concrete). The pipe should be isolated from direct contact with the concrete. When concrete anchors are being poured, wrap the pipe with rubber or other protective material. If the anchor is for axial movement, use the solvent welding process to weld a split collar to the pipe to provide the needed protection. When solvent welding collars on the pipe, allow 48 hours for drying time before pouring concrete.

Q3. What is the main purpose of a sanitary sewage collection system?

- Q4. *What six items are required for pipe installation?*
- Q5. *A trench bottom should be sloped in what direction?*
- Q6. *What person sets and checks the elevation of pipe that is laid in trenches?*
- Q7. *What are the four types of sanitary drainage piping used in underground sanitary plumbing?*
- Q8. *What is the laying length of cast-iron soil pipe?*
- Q9. *Vitrified clay pipe can be cut with a chisel. It can also be cut with what other piece of equipment?*
- Q10. *PVC is what type of pipe? What does the acronym "PVC" mean?*
- Q11. *What is the difference between a fillet-welded joint and a fusion-welded joint for plastic (PVC) pipe?*

SANITARY DRAINAGE INSTALLATION

LEARNING OBJECTIVE: *Recognize the methods of installing and testing sanitary drainage piping.*

Small pipes can be assembled and joined in sections on top of the ground and laid in the trench by hand. Large, heavy pipes are usually laid in the trench and then joined. These pipes may be lowered into the trench by rope, cable, or chain. Larger pipe may require the use of machinery operated by an Equipment Operator.

When assembling and joining pipes outside the trench, make sure you are a safe distance from the edge of the trench to prevent cave-ins. Also, do not leave tools or materials near the edge of a trench where they may be knocked off and injure someone working in the trench or cause a worker to lose his or her footing and fall into the trench.

Sewer pipes should be laid on a compacted bed of sand, gravel, or material taken from the trench excavation, if suitable, to provide a slightly yielding and uniform bearing. This step assures safe support for the pipe, the fill, and the surface loads. When pipes are laid on sand, gravel, or similar material, the weight of the pipe usually provides a suitable equalizing bed.

Pipelines should be embedded carefully, so they do not settle at any point. Settling causes suspended matter to collect in the lower portion of the pipe

restricting the flow and reducing the handling capacity of the line.

TRENCHING AND GRADING

After you have laid the pipes, your next step is to check the grade and align the pipeline. This is very important in installing an underground sewer system. Remember, sewage does not flow uphill, unless of course you are using a pump, such as a lift station does. The pipe should be laid, so the flow of the sanitary waste in each length of pipe flows from the hub end to the spigot end or we could say the hub end is upstream. Each length of pipe should be placed starting at the lowest elevation and working up the grade; therefore, the spigot is inserted into the hub of the length laid previously. Each length should be checked as to its grade and alignment before the next length is placed.

When you are grading for the proper pitch per foot, the method shown in figure 3-31 may be used as a guide. This figure shows a ditch with batter boards used in transferring line and grade to trench; also, a stick for checking grade is shown in position.

An Engineering Aid (EA) is responsible for setting the batter boards at the proper level for the job at hand. Batter boards are placed across the trench at about 25- to 50-foot intervals. Elevations are run by an EA, and a mark is placed on the stakes at some even-foot distance above the invert (the lowest point on the inside of the pipe) of the sewer. A nail is then driven in the top of the batter boards, and a cord is stretched from board to board. The center line for the pipe is then transferred from the cord to the bottom of the trench by means of a plumb bob. Grade is transferred by means of a stick, marked in even-foot marks, having a short piece fastened at a right angle to its lower end. Grade is checked by placing the short piece on the invert of each length of sewer pipe and aligning the proper mark on the grade rod to the cord.

TESTING

After you complete the rough-in piping of a project, test and inspect all the piping for leaks. The purpose of testing the pipeline is to make sure the joints are tight enough to withstand working pressure. Since a sewer line of this type flows by gravity drainage, the test procedures are different than those described later under the heading of "Water Service."

Before the pipe is covered with dirt, it must be tested for leakage. There are several methods of

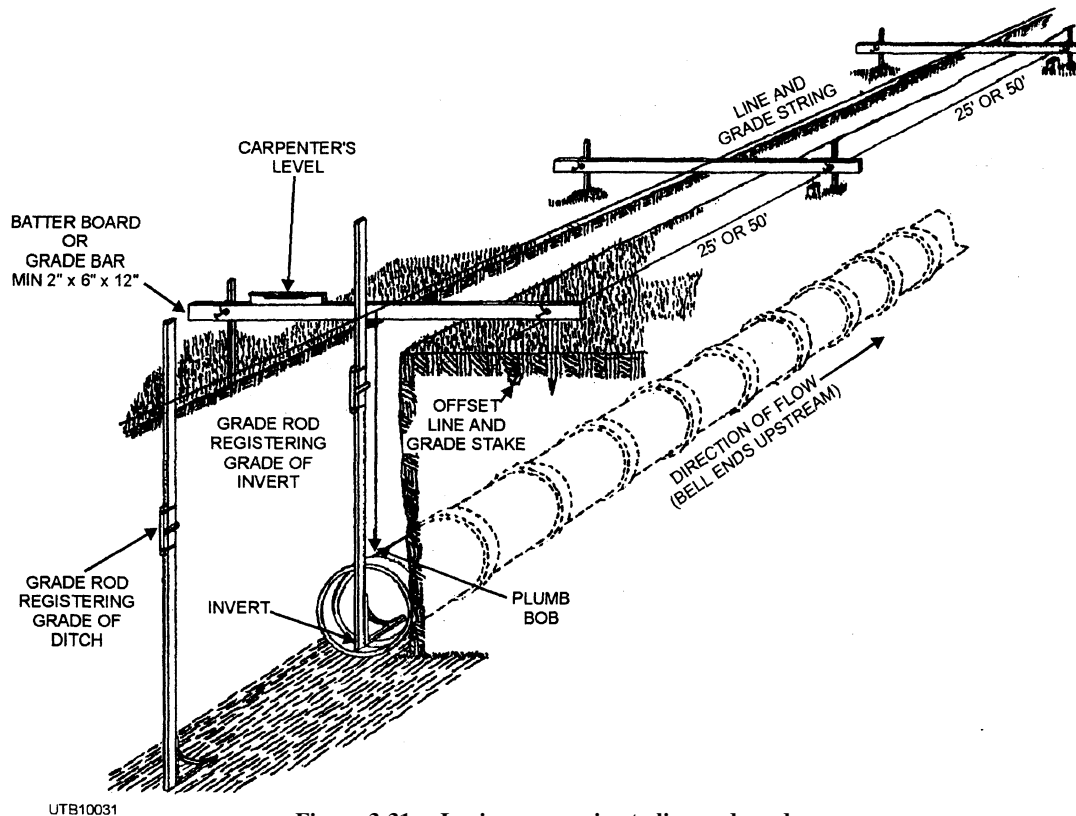


Figure 3-31.—Laying sewer pipe to line and grade.

effecting this test. The most widely used test is the water test, although an air test or odor test may be used.

Water Test

Here are the main steps in making a water test. At the lowest point of the section to be tested, insert a test plug in the open end of the pipe or a test tee, like those shown in figure 3-32, and plug other openings. Fill the pipe to its highest level with water; a 10-foot head is required. Leave the water in the pipe for at least 15 minutes before starting the test. This allows the oakum to soak up some water before you look for leaks. If necessary, refill the pipe to overflow and check each joint for leaks.

Air Test

Before making an air test, fill the system with water and allow it to stand until the oakum expands at the joints. Drain the water from the lines and reinsert the test plug. Close all openings and apply air pressure of at least 5 pounds per square inch (psi). In a satisfactory test, the line should hold 5 pounds psi for 15 minutes. If it does not, cover the joints with a soapy water solution and check for bubbles at the leak.

Odor Test

Before making an odor test, plug all openings in the sewer and the branches. After sealing the openings, pour 2 ounces of oil of peppermint in each line or stack. Then pour approximately 1 gallon of boiling water in the stack and seal it. The odor of peppermint at any point in the installation indicates a leak. The inspector, checking the installation for leaks, should not be near the oil of peppermint at any time before the inspection. Such exposure rapidly dulls his or her sensitivity to the odor of peppermint. The peppermint test is not as conclusive as the water and air tests described above, since no pressure is on the pipe.

NOTE

Repeat tests as necessary until all the leaks are located and repaired.

Where a system of pipelines has been installed using gaskets, test one floor at a time. Should there be more than one floor to be tested, be sure all bends, changes of direction, and ends of runs are restrained (limited).

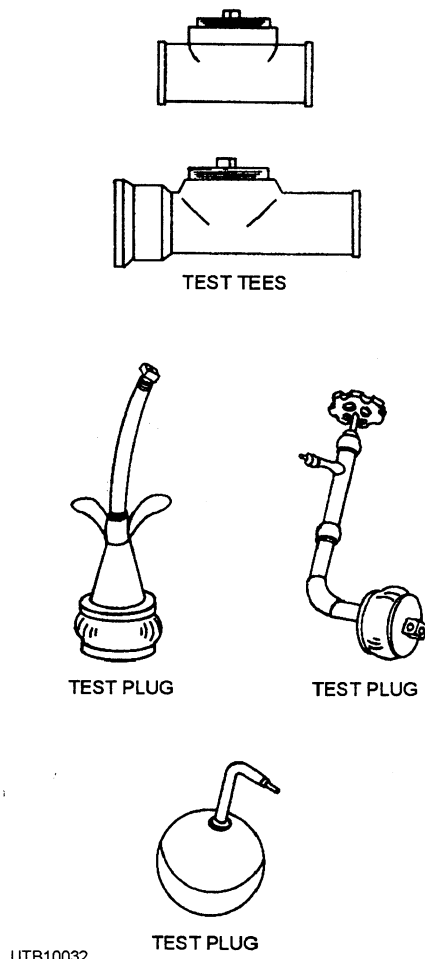


Figure 3-32.—Test plugs and test tees.

MANHOLES

Normally, it is not your responsibility as a Utilitiesman to construct manholes. They are made of concrete or brick; however, you may be working with the Builders in spotting the location for the manholes. Figure 3-33 shows a typical drop manhole.

Watertight manholes are made of brick or concrete, 4 feet in diameter at sewer level, and should be placed at junctions and bends in the line. They are spaced preferably 300 feet apart for 8-inch pipe, 400 feet apart for 10- to 15-inch pipe, 500 feet apart for 18- to 48-inch pipe, and 600 feet apart for larger sizes. Sewers should be laid straight to line and grade between manholes, and changes in the size of sewer lines must take place only at the manholes. The crown of the outlet pipe from a manhole should be on a line with or below the crown of the inlet pipe. When the invert of the inlet pipe is more than 2 feet above that of the outlet pipe, a drop manhole must be provided to conduct the sewage to a lower level with minimum turbulence.

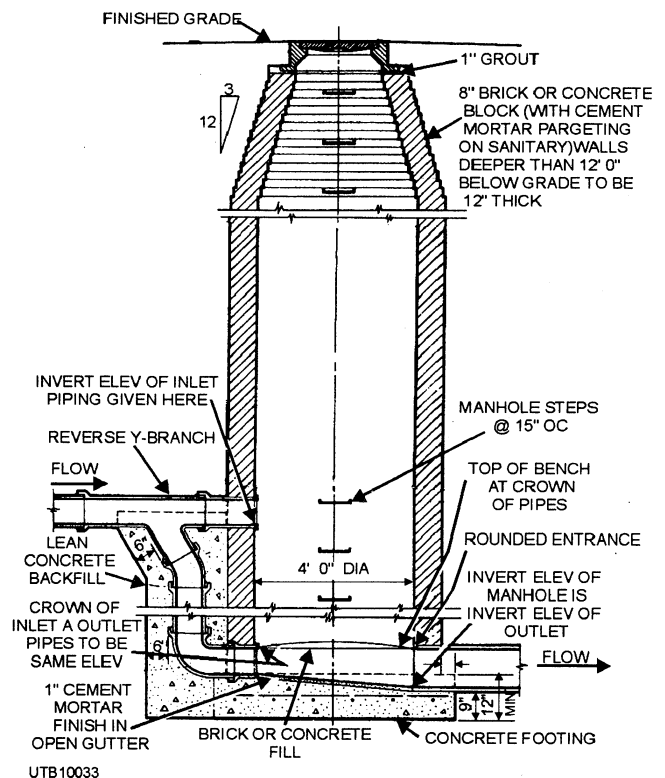


Figure 3-33.—Standard drop manhole for sanitary or storm drainage systems.

BACKFILLING AND TAMPING

After all pipelines have been laid and tested, they are ready to be covered; this process is known as backfilling and tamping. The method described below should work for sewer lines.

Fine material, free from stones and other debris, is tamped in uniform layers with a small hand- or air-operated tamper under, around, and over the pipe. Use a hand shovel to backfill the ditch until the pipe has a 2-foot covering. This fill should be placed in the ditch and tamped in 4-inch layers or less. It should proceed evenly on each side of the pipe, so injurious side pressure cannot occur. Make sure you do NOT walk on the pipe until you have at least 1 foot of soil tamped over the pipe. Until 2 feet of fill has been placed over the pipe, the filling should be done carefully with hand shovels; after that, machinery may be used for faster backfilling. However, do not let the machinery run over the line.

Puddling, or flooding, with water to consolidate the backfill should NOT be done for a sewer line. The sections of pipe are in short lengths and tend to settle very rapidly to form pockets or low spots in the line.

Q12. What is the required head height for a water test?

Q13. For an air test to be satisfactory, the system should hold 5 psi for what period of time?

Q14. What type of oil should be used for an odor test?

Q15. A manhole should be what diameter at the sewer level?

Q16. Earth fill should be placed in the trench over the pipe in layers of what thickness?

ABOVEGROUND SANITARY PIPING

LEARNING OBJECTIVE: *Identify pipe, traps, vents, and installation methods for aboveground sanitary drainage.*

After the underground piping is installed for a sewer system, the next phase is to install the aboveground piping. Information on materials applicable to the installation of aboveground sewage piping is provided in the following sections. Installation procedures are the same for aboveground and underground sewer pipe.

TYPES OF PIPE

A number of different types of pipes are used in the aboveground and interior parts of a plumbing system. Some of the common types of pipes are discussed briefly below.

While **GALVANIZED WROUGHT-IRON PIPE** is an excellent material for aboveground plumbing, it is costly. It is available in lengths from 18 to 22 feet. Galvanized wrought-iron pipe is constructed of wrought iron dipped in molten zinc to protect it from corrosion and provide high resistance to acid waste.

ACID-RESISTANT CAST-IRON PIPE is composed of an alloy of cast iron and silicon. It is used to serve chemical laboratories and other installations through which acid waste flows. In handling acid-resistant pipe, such as Durion™, be careful because it is very brittle and cracks easily. It is cast in 5-foot lengths and comes in single and double hubs.

BRASS PIPE consists of an alloy of zinc and copper. Brass pipe has a smooth interior and can resist most acids; however, it is expensive. It is available in 20-foot lengths; because it tends to bend, it must be supported at intervals of 8 to 10 feet.

LEAD or LEAD-LINED STEEL PIPE is sometimes used to carry distilled water for batteries; however, tin-lined, block tin, glass, or some types of plastic pipe must be used where no impurities are

acceptable. Because it bends easily, lead pipe must be well-supported. It is available in three weights: (1) standard, (2) common, and (3) extra heavy. The standard weight is most commonly used.

COPPER PIPE. is suitable for use in waste, vent, and water installations. Remember that ammonia and water corrode copper and bronze lines. Also, when copper is used for waste pipe installations, always make sure it is rigid to overcome sagging. You can obtain the pipe in convenient lengths, then cut it to size for the job at hand.

PLASTIC PIPE is also suitable for use aboveground for sewage, venting, and water.

TRAPS

A number of different types of traps are available; however, the trap most commonly used with plumbing fixtures is the P-trap (fig. 3-34). Traps are required because they prevent sewer gases from entering a building and causing serious illness or death.

The term *trap seal* refers to the water being held in the bent portion of a fixture trap (fig. 3-34). True to its name, the trap seal forms a seal against the passage of sewer gases through the trap and into the building. The most frequently used seal trap has a depth of 2 inches between the overflow and the dip. The deep seal trap has a depth of 4 inches.

The P-trap gets its name because of its general shape—that of the letter *P*. It comes in sizes from 1 1/4 to 6 inches in diameter. Various types of P-traps are available, so designs may differ from one manufacturer to another. The P-trap is usually made

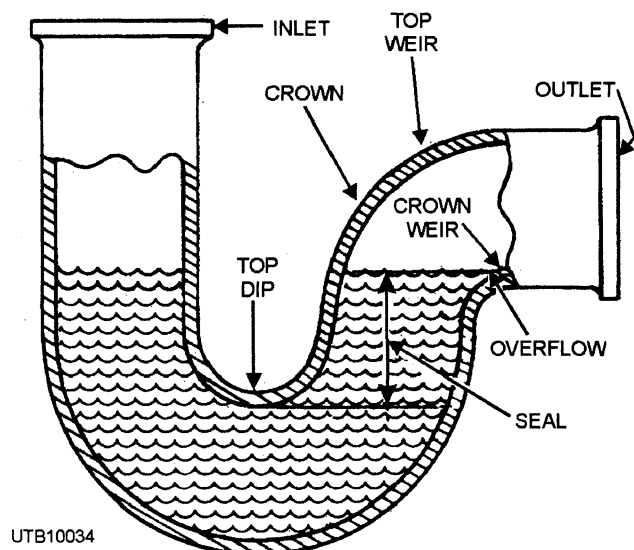


Figure 3-34.—P-trap.

of nickel or chrome-plated brass, malleable galvanized; cast iron, other metal alloys, and plastic.

The P-trap is used for fixtures suspended from the walls or supported on pedestals, for instance, lavatories, sinks, and urinals. At times the P-trap may also be suitable in showers, baths, and installations that do not waste large amounts of water.

When using a P-trap for fixtures suspended from the wall, you should install it as close to the fixture as possible. Be careful not to install a vertical leg that is too long between the trap and the fixture. It is also important for the horizontal leg connection to the waste system to be short for ventilation purposes.

VENTS

To prevent the siphonage of a trap seal in fixture traps and allow gravity flow of drainage, you must let atmospheric air from outside the building into the piping system to the outlet (or discharge) end of the trap. The air is supplied through pipes called VENTS. This air provides pressure on the outlet end of the seal equal to pressure on the inlet end.

Atmospheric pressure at sea level is about 14.7 pounds per square inch. This pressure remains virtually constant on the inlet end of the water seal. Obviously, a greater or lesser amount of pressure on the outlet end of the trap seal forces the water in the direction of least resistance. Since the air supplied by the vent to the outlet end provides a pressure equal to that at the inlet end of the trap, the trap seal cannot escape through siphonage.

All vent systems should be provided with a main vent or vent stack and a main soil and waste vent. A “main vent” may be defined as the principal artery of the venting system, and vent branches may be connected to the main vent and run undiminished in size as directly as possible from the building drain to the open air above the roof. The MAIN SOIL AND WASTE STACK, as shown in figure 3-8, is installed in a vertical position.

The term *main soil and waste vent*, or *soil stack vent*, refers to the portion of the stack extending above the highest fixture branch. In figure 3-8, this vent extends through the roof. Actually, it is an extension of the main soil and waste stack.

Common Types of Vents

Various types of vents are used in the ventilation of fixtures; even in the best of installations, you may find

several different types of vents. The selection of a particular type of vent depends largely on the manner in which the plumbing fixtures are located and grouped. Some of the common types of vents you may use frequently in your work are mentioned briefly below. An **INDIVIDUAL VENT**, also known as a **BACK VENT**, is a vent that connects the main vent with the individual trap underneath or behind a fixture. This method of venting is shown in figure 3-35. When you install two or more fixtures on an individual vent basis, ensure the leg (see illustration) connecting individual vents to the main vent is large enough to carry the total load.

A **COMMON VENT** vents two traps to a single vent pipe, as shown in figure 3-36. The unit vent can be used when a pair of lavatories are installed side by side, as well as when they are hung back to back on

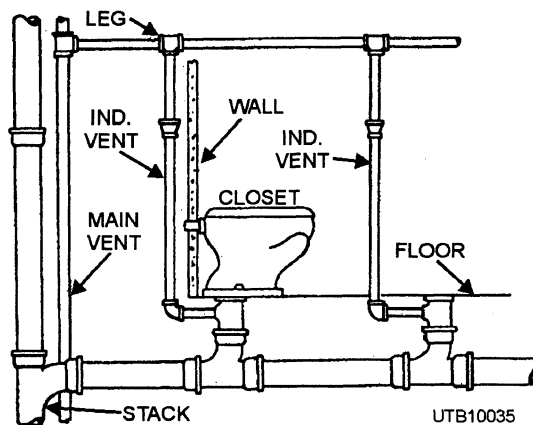


Figure 3-35.—Individual (or back) venting.

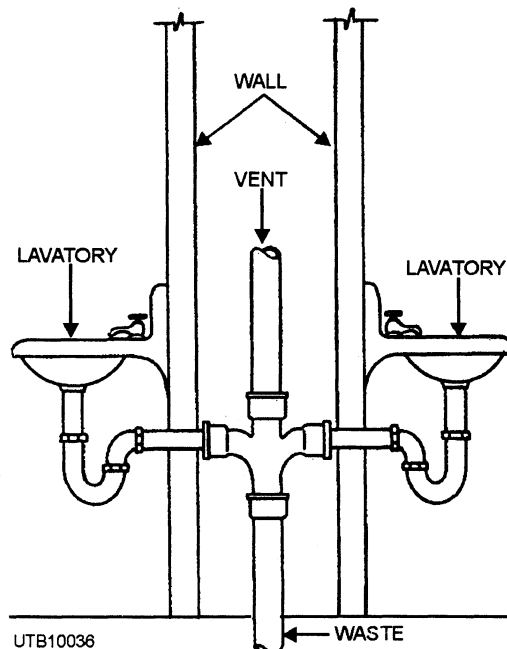
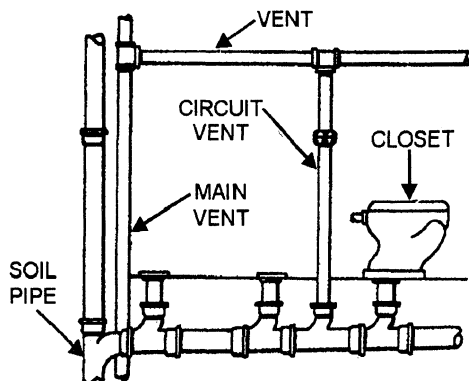


Figure 3-36—Two fixtures unit vented.

either side of a partition (as shown in the illustration). A point to note is that the waste from both fixtures discharges into a double sanitary tee.

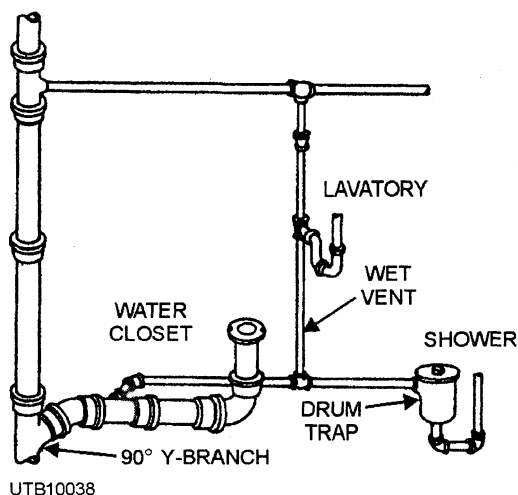
A **CIRCUIT VENT** serves a group of fixtures. As shown in figure 3-37, a circuit vent extends from the main vent to a position on the horizontal branch between the last two fixture connections. Make sure that a maximum of eight fixtures are put on any one circuit. If you have more than eight fixtures to be circuit vented, use two circuits instead of one. In this type of vent, water and waste discharged by the last fixture tends to scour the vents of other fixtures on the line.

A vent pipe, in which liquid wastes flow through a portion of it, is known as a **WET VENT**. A **LOOP VENT** is the same, except it connects into the stack unit to form a loop. This type of vent may be used on a small group of bathroom fixtures, such as a lavatory, water closet, and shower, as shown in figure 3-38. The pipe for a wet vent installation should be sized to take care of the lavatory, the water closet, and the shower.



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Figure 3-37.—Water closets circuit vented.



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Figure 3-38.—Wet vent.

NOTE

When you are draining more than four fixture units, the wet vent should never be under 2 inches in diameter. A water closet must not drain into a wet vent.

As shown in figure 3-38, the lavatory should be individually vented. This is necessary to prevent loss of the trap seal through indirect siphonage. Another point to note with the lavatory is that the relatively clean water discharged from it tends to scour the wet vent, preventing an excessive buildup of waste material in the vent.

Installation Pointers

A venting system must be installed properly with little repair and upkeep. This section points out your duties in installing vent systems.

Refer to figure 3-39. Notice that a **MAIN VENT TEE** forms a junction between the main vent and the main soil and waste vent. This is a tapped tee having a stack side outlet. It should be installed by caulking in the vertical stack, at least 6 inches above the overflow level of the highest fixture connected. After this has been done, the vertical stack should be extended, full size or larger, through the roof to form the vent terminal. The pipe must extend at least 6 inches above the roof. If the roof is used for other than weather protection, the vent terminal must be 7 feet above the roof. The opening in the roof through which the main soil and waste vent runs must be properly waterproofed. Roof flashing is used for this purpose. Roof flashing is made of galvanized iron or copper. Flashing is available in different sizes. Normally, the size of flashing needed for a job is determined by the size of the main soil and waste vent.

When installing roof flashing on a shingled roof, extend it under two courses of shingles above the pipe. On a flat roof, place it between layers of the roofing material and have the finishing layer over the top of the flashing. To complete the installation on either type of roof, always apply a coat of roofing cement as added protection against leakage.

In a cold climate, you must think about ways to prevent closure of the main soil and waste vent at the roof outlet by freezing. The air discharged by the main stack and waste vent is humid and condenses. This

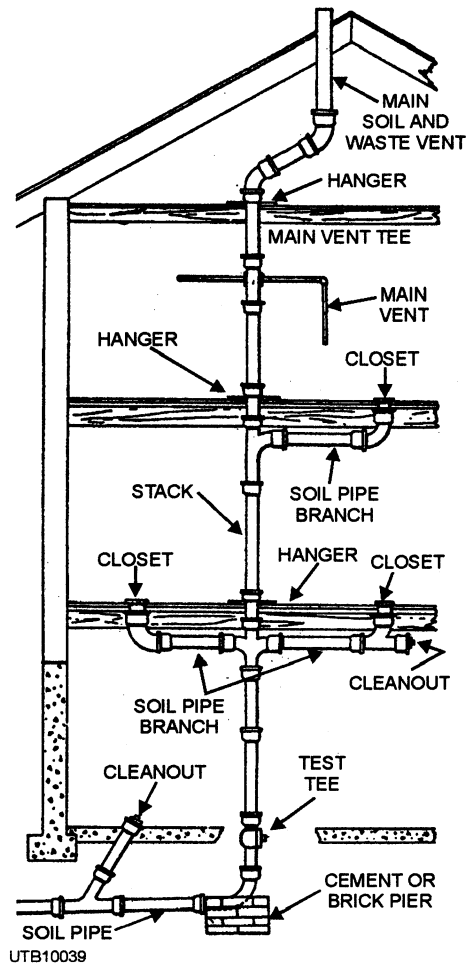


Figure 3-39.—Soil pipe branches.

condensation freezes when exposed to low temperatures.

One way to prevent freezing is to increase the pipe to a size or two larger than the vertical vent passing through the roof; or, install high-lead flashing to provide an insulating pocket of air between the flashing and the end of the main soil and waste vent above the roof. Being open to the heat of the building, the air pocket allows an intermediate warming area for gases leaving the main soil and waste vent.

Materials used in vent piping ordinarily include galvanized pipe, cast-iron soil pipe, and at times, brass, copper, and plastic pipe. Asbestos-cement pipe can also be used for venting both soil and waste pipe. A single length of this pipe is often sufficient for venting a stack. For such an installation, pipe is available with a machined end. This end is placed in the bell of the soil or waste pipe, and the connection is made by yarning, leading, and caulking.

In all phases of the venting system, do your best to use proper-sized piping. Remember, the diameter of

the vent stack or main vent must not be less than 2 inches. The actual diameter depends on the developed length of the vent stack and on the number of fixture units installed on the soil or waste stack. The diameter of a stack vent should be at least as large as that of the soil or waste stack.

Both soil and waste pipe BRANCHES are horizontal branch takeoffs that connect various fixtures and the vertical stack (fig. 3-39). One method of installing a branch takeoff from the vertical stack is to use a Y-branch with a 1/8 bend caulked into it. Another method is to use a sanitary tee, which is an extra short pattern 90-degree Y-branch. Of these two methods, the sanitary tee is better because you eliminate one fitting and an extra caulked joint; both are required for the 1/8 bend takeoff. Some local codes allow you to connect more fixture units to a given size of stack when a combination Y and 1/8 bend is used. The combination Y and 1/8 bend may be more desirable than the sanitary tee. Once either fitting is caulked into place, the horizontal branch can be extended as necessary with lengths of soil pipe. They, too, are joined by caulking.

Pipes carrying waste should be graded downward to ensure complete drainage. Horizontal vents should be slightly pitched to facilitate drainage of condensation.

In this chapter, only the basic types of vents and the locations where they are used have been covered; however, there are many forms of ventilation that can be applied to a plumbing installation. The types of vents used on a project are determined largely by the manner in which the plumbing fixtures are to be installed and where they are located.

As plumbers know, the subject of vents is the science of plumbing. Anyone can try to install piping for a plumbing system; however, if the system cannot carry waste away, the would-be plumber and the system are useless. For more information on venting, consult the *National Standard Plumbing Code-Illustrated*.

Q17. Acid-resistant cast-iron pipe is an alloy composed of what two elements?

Q18. What is a trap seal?

Q19. To prevent siphonage of seal traps in a plumbing system, what plumbing method should you use?

WATER SERVICE

LEARNING OBJECTIVE: *Identify types of pipe and methods for measuring, cutting, joining, and installing water service systems.*

The water-supply system for a building consists of the service pipe, the distributing pipes, and the connecting pipes, as well as fittings and control valves. Water carried by the system must meet accepted standards of purity. Two major functions of a water distribution system are (1) to carry potable water for domestic use and (2) to provide a high rate of flow for fire fighting.

TRENCHING

The method of trenching for waterlines is similar to that described earlier for sewer lines. In trenching for waterlines, it is not necessary to set batter boards since great care is not required in laying water pipes to grade because the water is under pressure. The pipes in a waterline may follow the contour of the earth's surface in a trench that is a minimum of 2 feet deep. Minimum depth of the ditch depends upon the depth of the frost line in the area. The trench should be wide enough to permit ease of working around the pipes and to allow earth to be placed during backfilling. Usually, the trench is not deep enough to require bracing or shoring.

Locate the trench at least 4 feet from a previously dug ditch, or trench, to help prevent cave-ins. Water pipes should be laid 1 foot above and 10 feet away from nearby sewers. This helps prevent the water distribution system from becoming contaminated by leaks. Sometimes the water main and sewer lines may cross each other. In such cases, the water pipe must cross over the top of the sewer line, so be careful to make all joints tight; however, check the local specifications before installing them in this manner.

The distribution system must be kept free from contamination caused by leaks, back siphonage from faulty plumbing, and cross-connections. The greatest hazard in a distribution system is cross-connection. This is one physical connection to another that is an unsafe or doubtful source of water or a connection or condition that will permit wastewater to enter the potable public supply.

PLACING WATER PIPE

An important phase in the installation of a water system is laying the underground water service pipes.

Information to aid you in laying these pipes is provided below.

Regardless of the pipe material used, sharp bends and dead ends should be anchored by rodding or concrete anchors. Where the pipe is setting in saddles, metal straps may be used. Even though the pipe is installed within a ditch, the straps help support and hold the pipe in place. Pipe should be founded on solid trench bottoms. Automatic air-release and vacuum valves should be installed at prominent peaks on long supply mains to permit escape of air while the pipe is being filled and entrance of air when it is being drained. Elsewhere in the distribution system, air normally can be released and taken in through service lines.

Flow in water pipes may be achieved by gravity with an elevated tank or by a pumping system. When pipe must be placed in a sloping trench, the slope should be as even as possible to keep the pipe from bending and breaking. After the trench is dug, lay the pipe and fittings alongside it. Before you start placing the pipe; shut off the water in the main supply line. The placing should start at the main supply tee.

BACKFILLING

When you are ready to backfill a ditch, tamp the soil around the pipe by hand or use water. In backfilling, keep the pipe straight and minimize settlement. Soil used to backfill around the pipe should be as free as possible from rocks and debris. When you throw fill material directly on the exposed pipe, you could damage the pipe or move it out of alignment. **DROP THE FILL MATERIAL ON BOTH SIDES OF THE PIPE AT THE SAME TIME.** When you have water available, use it instead of the tamper, especially when you have a short run to backfill. Fill the ditch completely with loose soil. Attach a piece of pipe to a water hose and push it through the loosely replaced soil until it touches the water main. Turn on the water and let it run until the water appears on the surface. This method allows all the earth to be replaced except the volume equal to that of the pipe.

WATER-SUPPLY PIPING

Piping materials used in water-supply systems include cast-iron pressure pipe, copper pipe, galvanized pipe, cement-asbestos pipe, ductile iron pipe, concrete pipe, and PV-class water pipe. Some of the main characteristics of pipe made from these

materials and the equipment used are presented below.

Cast-Iron Pressure Pipe (For Water Mains)

The cast-iron pipe used for a water distribution system is somewhat different from that used for waste systems. Some of the major differences are in the length of the pipe, the joints, and the lining. Cast-iron soil pipe for waste, as you know, comes in 5-foot and 10-foot lengths. Cast-iron pressure pipe for water mains comes in 20-foot lengths with either bell-and-spigot or mechanical (gland-type) joints. This pipe may be coated with coal-tar pitch or be cement-lined; however, uncoated pipe is available if needed for other purposes.

MEASURING AND CUTTING.—Cast-iron pressure pipe is measured by the inside diameter; a ruler or tape is frequently used for measuring. With a cement lining, the lining goes beyond the inside diameter of the pipe, so you have to allow for this reduced inside dimensioning.

To cut cast-iron water pipe to the desired length, use either a hand-operated chain cutter or a power hacksaw. Because of the construction of this pipe, it does not need reaming after cutting; but, you can use a file to dress down the cut when necessary.

FITTINGS.—Three major types of fittings for joining cast-iron pipes in water service are tees, elbows, and couplings. Since these fittings look like those used for sewer lines, a detailed description need not be provided here.

JOINING.—In water service lines, bell-and-spigot cast-iron pipe is joined with lead, lead wool, or sometimes a sulfur compound. Specially prepared treated paper may also be used.

Before making a joint, you should first check each length of pipe for cracks or splits. After eyeing the pipe for defects, rap it with a hammer. With a little experience, you will know the difference between a good pipe and a bad pipe (cracked or split).

Next, wrap the yarn around the spigot end, place it in the bell of the previously laid length, then straighten and adjust it with a yarning iron. Use enough yarn to fill the joint within approximately 2 inches of the face of the bell. Then clamp a joint runner in place around the joint, so it fits tightly against the outer edge of the bell. The lead should then be poured into the V-shaped opening left at the top by the clamped joint runner. This

lead fills the space between the yam and the runner. This joint must be made in one pouring for best results. After the lead has hardened (about 10 seconds), the runner is removed, and the lead, which shrinks while cooling, is expanded by caulking until it makes a tight fit. Caulking requires skill; hammer blows that are too heavy could split the bell, or blows that are too light could leave a loose joint.

Lead wool is lead in shredded form that does not require melting. Lead wool is sometimes used when water is encountered in a trench. In this process, more yarn is used; the joint is filled to about 1 inch of the face of the bell. Lead wool requires more time in caulking than poured lead.

A sulfur compound is melted on the job, like lead, but at a lower temperature. It is then poured into a joint prepared for a cast-lead joint. The fact that it is light in weight is its primary advantage. It requires no caulking and provides a strong joint that is unlikely to blow out. Initially, joints of sulfur compounds leak or sweat slightly, but they tighten up in a short time. Since the joints are rigid, they should not be used to connect a newly laid line to an old one, as the settlement of a new line can cause a crack. A lead joint should be used at the connection.

Mechanical joints are made with rubber sealing rings held in place by metal follower rings bolted to the pipe. This type of joint is designed to permit expansion and contraction of the pipe without injury to the joints.

Copper Pipe

Copper pipe and tubing with soldered joints or flared-tube connectors are used for water service. Copper is highly regarded because of its corrosion-resistant properties, flexibility, ease of installation, and low resistance to flow throughout its useful life.

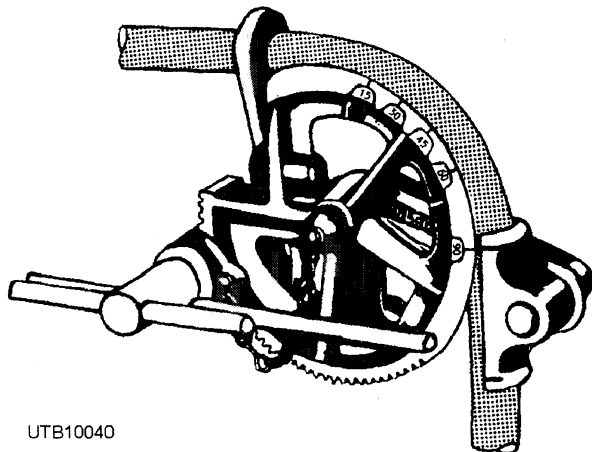
Three types of copper, designated as Types K, L, and M, are commonly used. Type K is used for underground service and general plumbing; Type L for general plumbing; and Type M with soldered fittings only. Types K and L copper come in either straight 20-foot lengths of hard temper or in coils of 50 to 100 feet, soft temper. Type M comes in straight 20-foot lengths, hard drawn only.

Another type of copper, Type DWV (drain, waste, and vent), is used only in aboveground soil, waste, and vent lines. It is furnished in hard temper only and in sizes from 1 1/4 to 8 inches. It is available in 12-foot lengths as well as the standard 20-foot lengths.

The process used to soften copper is called “annealing.” The word *anneal* means to soften thoroughly and render less brittle. Copper is unlike steel in many respects. If copper is bent often, it could break when you try to bend it again. Should the pressure on a copper tube increase or decrease too much, the tube could break. Vibration also makes copper tubing break.

To soften steel, heat it to a cherry red and cool it very slowly. The slower it is cooled, the softer the steel becomes. With copper, the opposite is true. Copper is heated uniformly to a dull red and then quenched (dipped) in water (for water service). The faster it is cooled, the softer the copper becomes.

BENDING.—Copper, properly annealed, can be bent by hand when sharp bends are not desired. Copper partially collapses during the bending process if a tubing bender is not used or if the copper is not filled with some kind of easily removable material, such as sand. Simple bends can also be made by wrapping the outside of the copper tightly with soft wire and bending the copper by hand; however, if a line must make a 45- or 90-degree bend, you should use a tubing bender. Hand-tubing benders are available for each size of copper. These benders assist you in making neat, accurate bends easily, quickly, and without marring the copper or restricting the flow through the copper. It is easy to make a bend but difficult to get the bend in the correct location on the copper and to the correct degree. Be certain that you have the correct size bender for the copper you intend to bend. A bender that is either too small or too large for the copper will make a faulty bend. Figure 3-40 shows one type of tubing bender. Figure 3-41 shows a typical one-story copper DWV system.



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Figure 3-40.—Portable copper pipe and tubing bender.

MEASURING.—Seven methods are used in measuring pipe or tubing. They are (1) end to end, (2) center to center, (3) end to center, (4) end to back, (5) center to back, (6) back to back, and (7) face to face. These measurements are also used in measuring threaded galvanized or black iron pipe.

The measurements are generally made with a ruler. Each of the seven methods mentioned above is explained below, and each one is shown in figure 3-42.

END TO END indicates a pipe threaded on both ends. The measurement is from one end of the pipe to the other end, including both threads.

CENTER TO CENTER means there is a fitting on each end of the pipe. The measurement is made from the center of the fitting on one end to the center of the fitting on the other end.

END TO CENTER method applies to pipe having a fitting on one end. The measurement is made from the end of the pipe to the center of the fitting.

END TO BACK also refers to pipe with a fitting on one end. The measurement is from the back of the fitting to the other end of the pipe.

CENTER TO BACK indicates a pipe with a fitting on each end. The measurement is taken from the center of one fitting to the back of the other fitting.

BACK TO BACK measurement refers to pipe with a fitting on each end. Here the measurement is from the back of one fitting to the back of the other fitting.

FACE TO FACE measurement refers to a pipe with a fitting on each end that has an opening directly across from the pipe it is connected to on both ends. Measure from the face of the opening to the face of the other fitting.

CUTTING AND REAMING.—Copper should be cut with a tubing cutter, when available. Mark the copper where it is to be cut and install the cutter so the cutter wheel is over the mark, and you can see the cutting wheel from the top view of the pipe, as shown in figure 3-43. Now turn the adjustment wheel or handle clockwise to force the cutter wheel against the copper. Continue revolving the cutter, turning the adjustment wheel slightly after each revolution until the copper is cut through and it separates.

Copper may be cut with a hacksaw, although a tubing cutter is preferable; however, be careful to cut the copper square if it is to be flared. Be sure to use a fine-toothed hacksaw blade, 32 teeth per inch, when cutting copper.

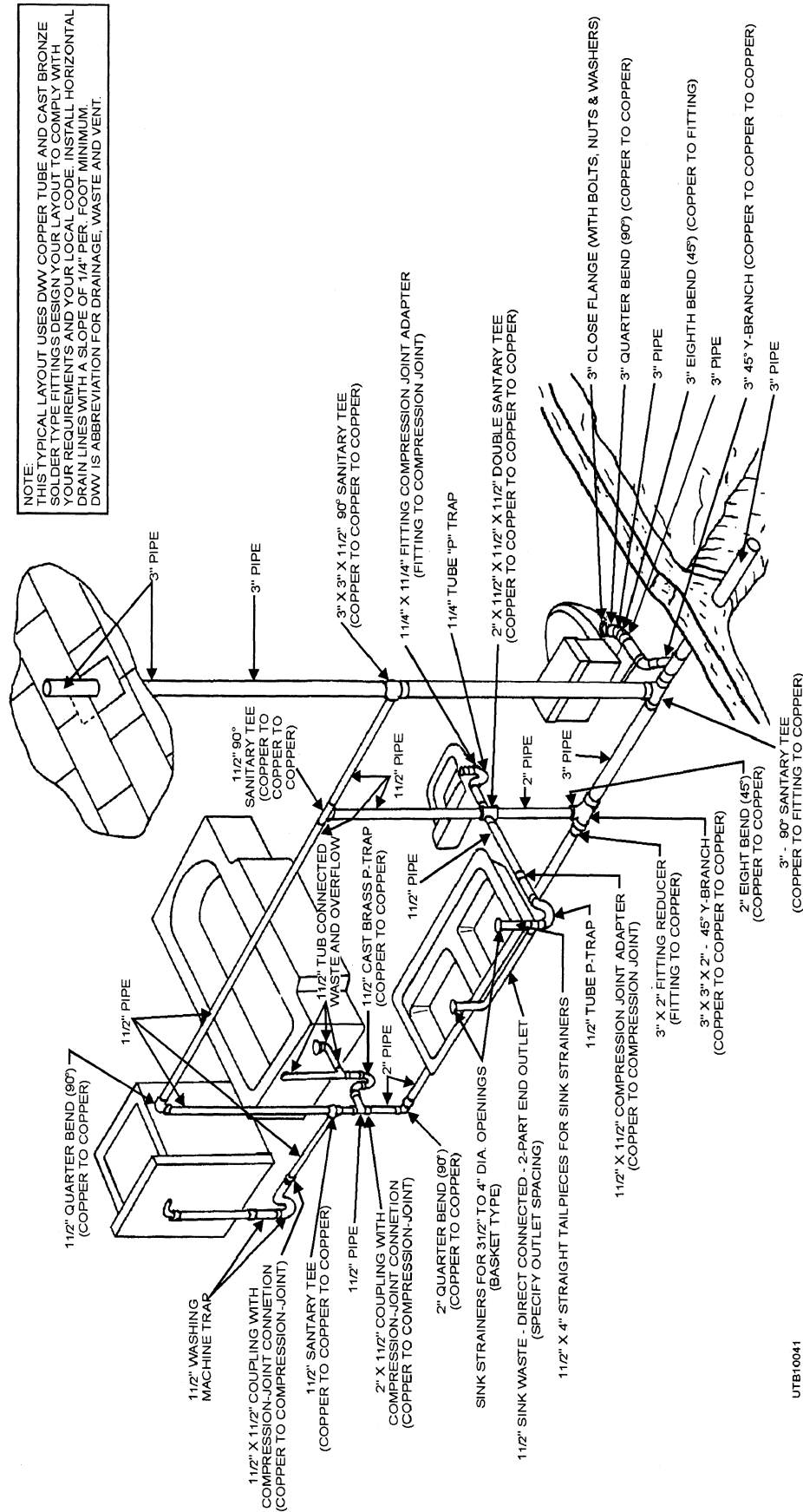


Figure 3-41.—Typical one-story copper DWV system.

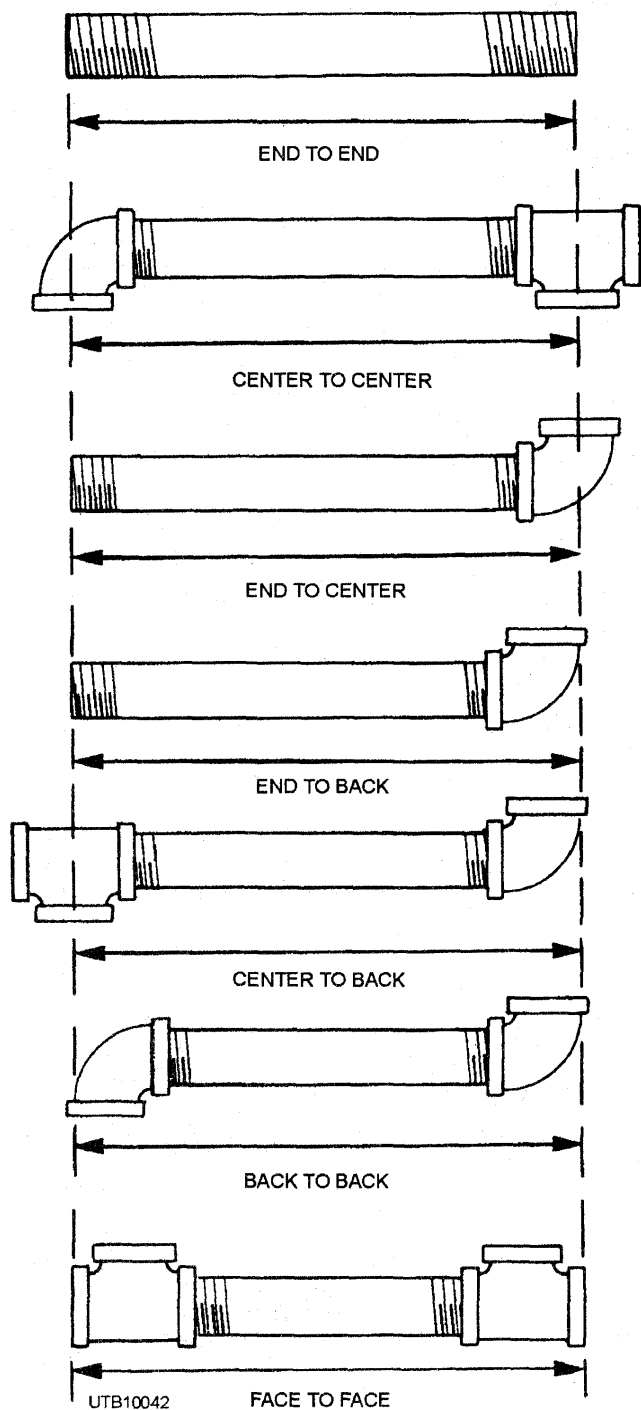


Figure 3-42.—Methods of measuring pipe and tubing.

After cutting the copper, remove the burr inside the cut with the reamer on the tubing cutter. Place the reamer in the end of the copper, and revolve the tubing cutter clockwise until the burr is removed.

JOINING.—When working with copper, you use both flared and sweated joints. “Flaring” is a method of forming the end of the copper into a funnel shape, so

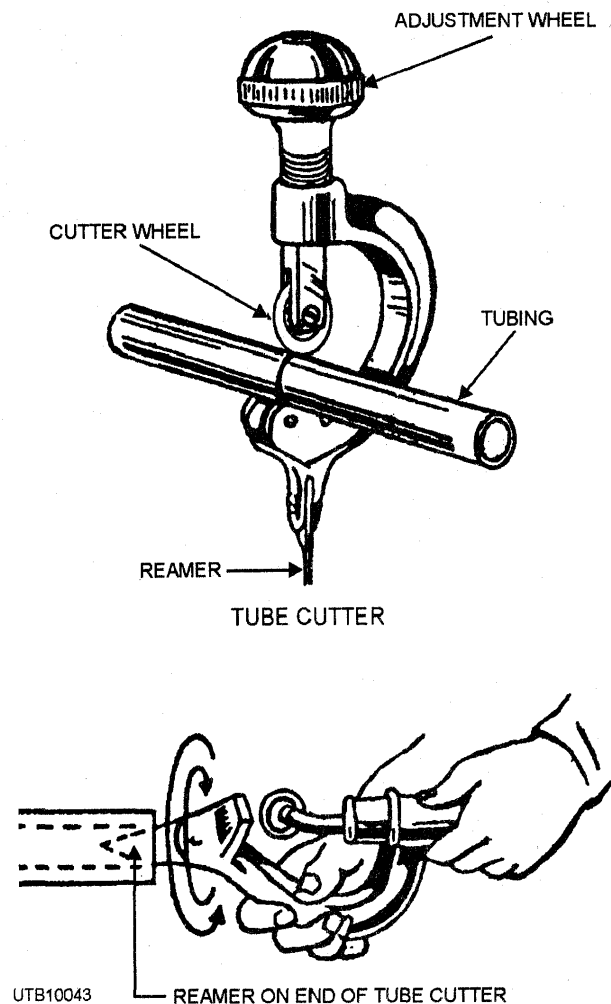


Figure 3-43.—Cutting and reaming copper tubing.

it can be held in a threaded fitting when a line joint is being made. Before a flare is made, slip a flare nut on the copper. A common error is forgetting to put the nut on before making the flare. For additional information on making flared connections, refer to *Use and Care of Hand Tools and Measuring Tools*, NAVEDTRA 12085. Figure 3-44 shows a few typical copper fittings.

A sweated joint is made with solder instead of threads or flares. When making a soldered joint with a sweat fitting, clean an inch or more of the end of the copper tubing with steel wool or 000 sandpaper until new metal appears. Clean the inside of the fitting in the same manner. Spread a thin film of paste flux on the tube end with a clean brush or applicator. Do not apply paste with your finger or an oily applicator.

Carefully insert the copper into the fitting to make them fit together very closely. Capillary action must spread the solder evenly and completely over the surfaces; however, the process is not effective with loose fits because of excess clearance. If the fit is loose, you may have to tin the end of the copper tube.

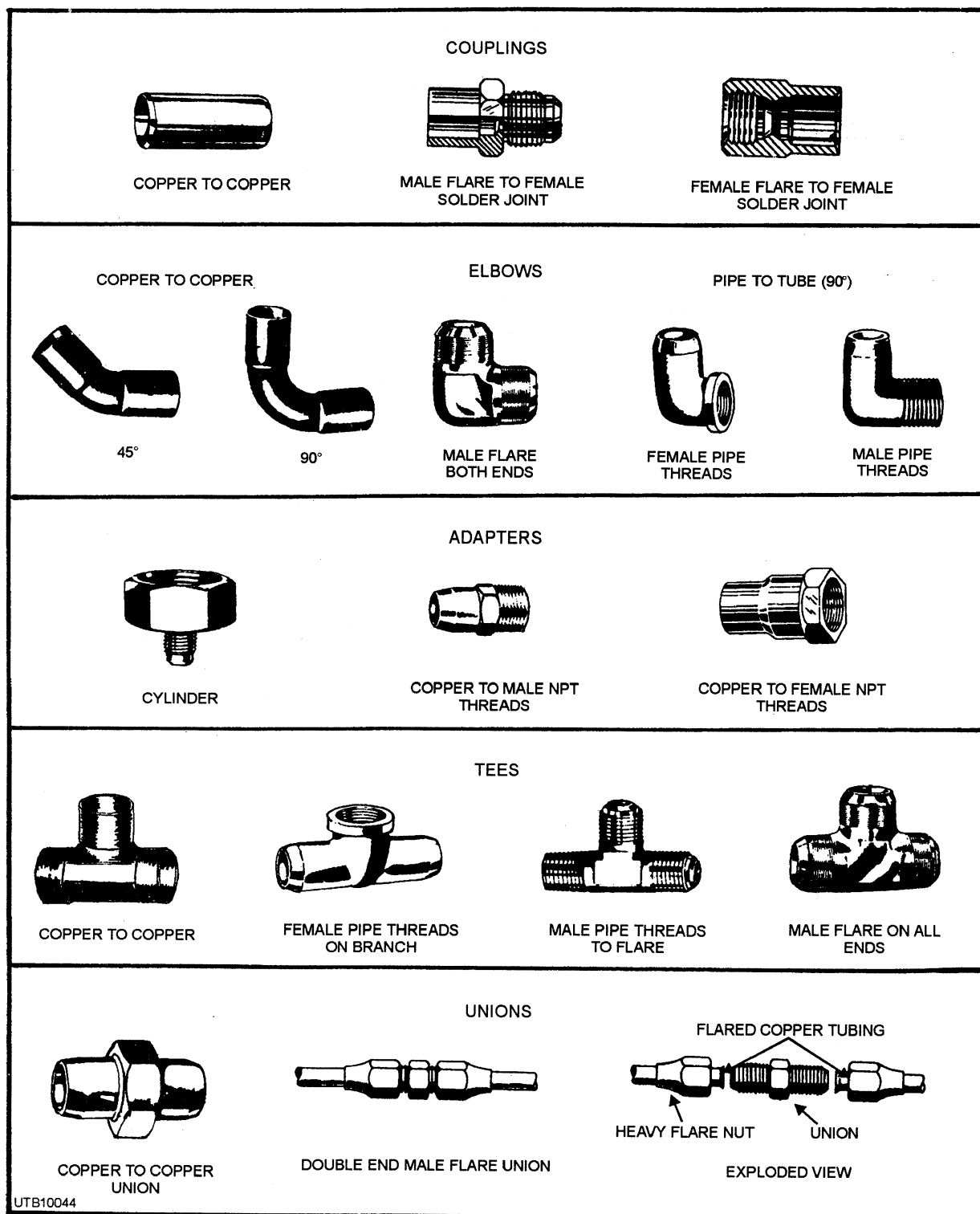


Figure 3-44.—Typical copper fittings.

“Tinning” is the process of applying a small amount of solder to the end of the copper before it is inserted into the sweat fitting.

In soft soldering, heat is applied directly to the metal with a flame. Various types of heat-generating equipment are available. In your work, however, you

generally use methylacetylene propadiene (MAPP) cutting/welding equipment or a Presto-lite heating unit.

The Presto-lite torch is ideal for SOFT SOLDERING because it delivers a small controllable flame. The Presto-lite unit consists of a small MAPP-gas cylinder,

regulator, rubber hose, torch, and two or more removable tips. This unit burns MAPP gas as a fuel in the presence of oxygen. Figure 3-45 gives you an idea of what the Presto-lite unit looks like.

When heating, apply heat to the fitting or thickest part until it reaches the melting temperature of the solder. Feed the solder at the edge of the fitting. When a continuous ring of solder appears at the end of the fitting, you have completed the joint.

After soldering is complete, clean the joints with a wire brush, soap and water, or emery cloth. Exercise caution to remove all flux from the joint after it is soldered. Any flux left on a joint causes corrosion.

In plumbing, you may occasionally be called upon to join copper pipe or tubing by silver brazing. You may also use silver brazing in making repairs to air-conditioning and refrigeration equipment, water systems, galley equipment, and so on.

In **SILVER BRAZING**, also called **SILVER SOLDERING** or **HARD SOLDERING**, joint members are fused by heating with a gas flame and silver alloy filler metal with a melting point above 800°F, but below the melting point of the base metal. The filler metal is distributed in the joint by capillary attraction.

Since capillary attraction is important in the silver brazing process, it may help you to understand what this term means. Perhaps the best way to understand

capillary attraction is to consider some everyday examples of the process. If you put one end of a strip of cloth in a glass of water and allow the other end to hang over the edge of the glass, the end of the cloth that is not in the water becomes wet. Water rises in the cloth by capillary attraction. The wick on an oil lamp can be lit because the oil rises in the wick by capillary attraction. In both examples, we have a **LIQUID** (water, oil) that moves into an opening in a **SOLID** (cloth, wick) by a process called “capillary attraction.” The basic rule of capillary attraction is that the distance the liquid is drawn into the opening in the joint depends on the size of the opening in the joint—the smaller the opening, the farther the liquid is drawn in.

In just the same way, capillary attraction causes the melted filler metal used in silver brazing to be drawn into the narrow clearance between the joining members. Capillary attraction does not work unless the filler metal is melted and unless the size of the opening is quite small; therefore, the application of heat and the use of a very small clearance between joining members are essential to silver brazing. The heat is necessary to melt the filler metal and to keep it molten; the small clearance is necessary to allow capillary attraction to draw the molten metal into the space between the joint members.

Silver-base alloys are commonly used as filler metal for brazing. Although filler metals other than silver-base alloys are often used, the technique for making a brazed joint is basically the same. The main difference is the amount of heat necessary to melt the filler metal. In all instances, this temperature is below the melting point of the base metals. Silver-brazed joints have high strength on ferrous and nonferrous metals. The strength of a joint that is made properly exceeds that of the metals joined. On stainless steel, it is possible to develop a joint tensile strength of approximately 130,000 pounds per square inch (psi). Since brazing with silver-based alloys is typical of brazing in general, it is especially interesting at this point to note the use of these materials as filler metal. This information applies equally to brazing with other filler metals that are distributed by capillary attraction.

Two methods are used to make joints between tubes and fittings in piping systems with silver-base brazing filler metal: the **INSERT** method and the **FEED-IN** method. With either method, the parts must be adequately supported during heating. The work must be held firmly in position until the brazing filler metal has completely solidified.

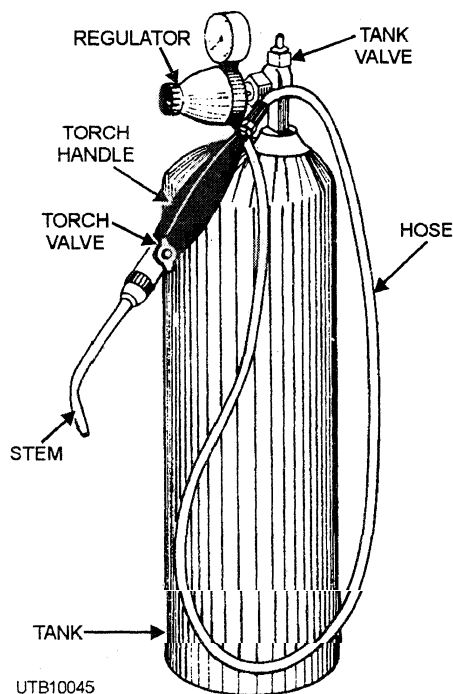


Figure 3-45.—Presto-lite heating unit.

When using the insert method, insert a strip of the silver-base filler metal in the joint before assembly. Before brazing the parts, clean them with emery cloth, steel wool, or an acceptable cleaning solvent. Apply flux with a brush. Next, fit the two parts together and align them. Then light the torch and direct the heat on the tube or thinner portion, as shown in figure 3-46. The lines drawn on the tube indicate the path of the torch while heating the tube.

Heat applied to the tubing causes it to swell and bring the surface of the tube into contact with the inside surface of the fitting. This closes the clearance area, forcing the flux from either end of the joint. Be sure to heat the entire circumference of the tube until flux begins to flow. Flux flow tells you that the tube has expanded sufficiently. This is the signal to proceed to the second phase of heating. As soon as the flux flows freely, about 6 seconds after you see the fluid, direct the flame to that portion of the fitting hub farthest from the junction of the tube and the fitting. Rotate the flame over the joint segment until brazing filler metal appears at the junction of the pipe and fitting. At that moment, flick the torch away so the flame wipes toward the pipe. This completes one segment of the joint. This procedure is repeated until all segments are completed. A satisfactory joint has a continuous ring of filler metal at the end of the fitting. The ring must also be smooth and concave.

With the feed-in method, the parts are heated to the correct temperature. Watching the behavior of the flux is the best way to determine the temperature of the joint as the heating progresses. First, the flux dries out as the moisture (water) boils off. Then the flux turns milky and starts to bubble at about 600°F. Finally, it turns into a clear liquid at about 1100°F. This last temperature is just short of the brazing temperature. The clear appearance of the flux indicates

the time to start adding the filler metal (silver solder). If the temperature and alignment are proper, the filler metal spreads over the metal surface and into the joint by capillary attraction. Make sure the filler metal penetrates the complete thickness of the metal for good bonding. Stop heating as soon as the filler metal has completely covered the surface of the joint. Then allow the joint to cool before moving, so the filler metal solidifies.

Gas-Welding Equipment

A number of different types of equipment are used in silver brazing. In your work, silver brazing can be accomplished by the use of methylacetylene propadiene (MAPP) cutting/welding equipment.

A commonly used oxygas welding outfit (fig. 3-47) consists of a cylinder of acetylene or MAPP gas or a cylinder of oxygen, two regulators, two lengths of hose with fittings, and a welding handle with tips. An oxygas outfit also is called a “welding rig.”

In addition to the basic equipment mentioned above, numerous types of auxiliary equipment are used in oxygas welding. A very important item is the spark igniter that is used to light the torch (view A, fig. 3-48). Another item you will use a lot is an apparatus wrench, the same or similar in design to that shown in view B, figure 3-48. The apparatus wrench is sometimes called a “gang wrench” because it fits all the connections on the welding rig. Note that the wrench shown has a raised opening in the handle that serves as an acetylene tank key. Other common accessories include tip cleaners, cylinder tracks, clamps, and holding jigs. Safety apparel, such as goggles, face shields, gloves, leather aprons, sleeves and leggings, also is essential and should be worn as required for the job at hand.

Oxygas welding equipment may be stationary or portable. A portable oxygas outfit, such as that shown in figure 3-49, is advantageous where the equipment must be moved around from one job to another.

To carry out your welding duties, you should understand the purpose and function of the basic pieces of equipment that make up the welding outfit. Before discussing the apparatus, look at the gases used in gas welding, particularly MAPP gas and oxygen.

MAPP GAS.—MAPP gas is an all-purpose industrial fuel that has the high-flame temperature of acetylene and the handling characteristics of propane.

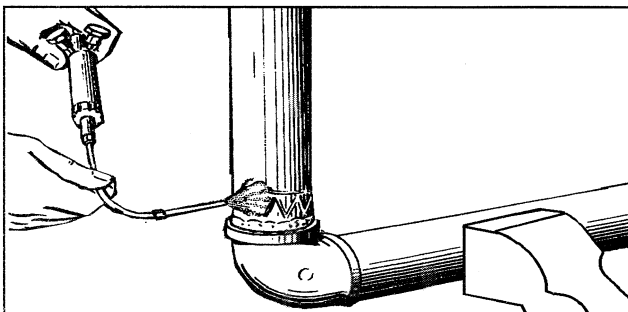


Figure 3-46.—Applying heat for brazing a tube and fitting.

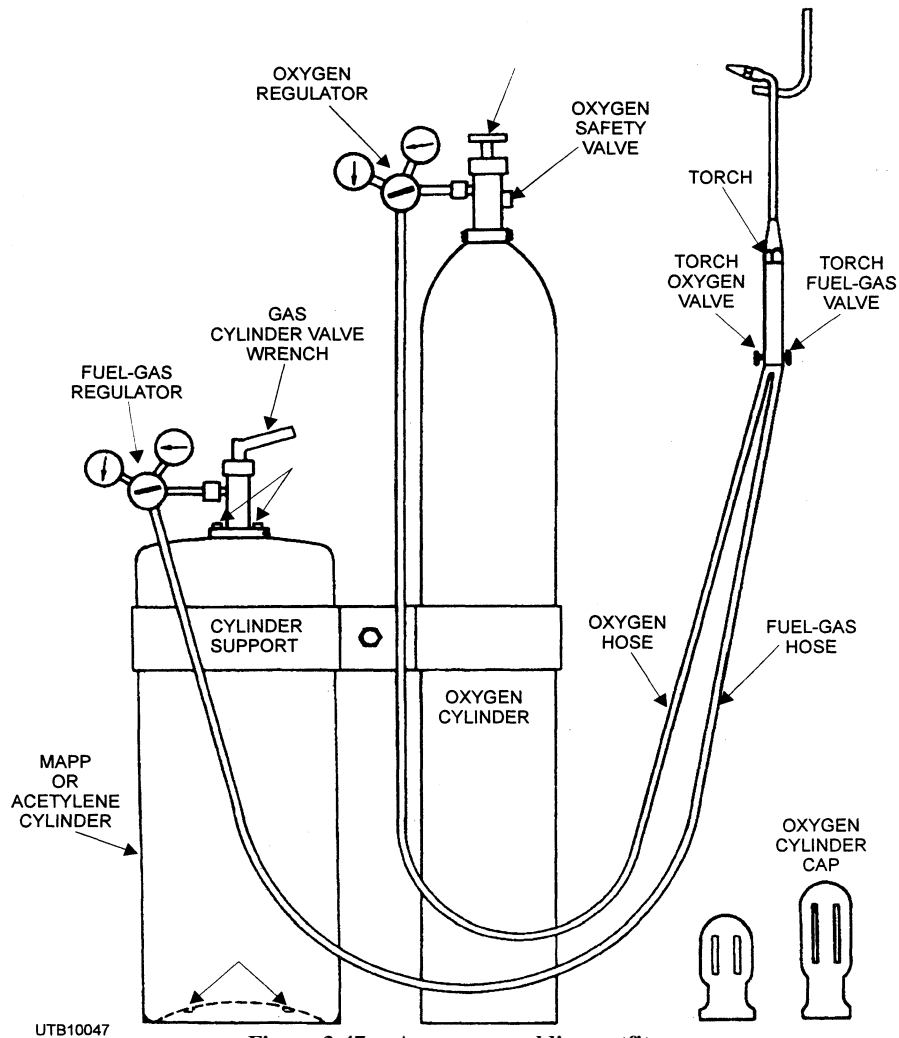
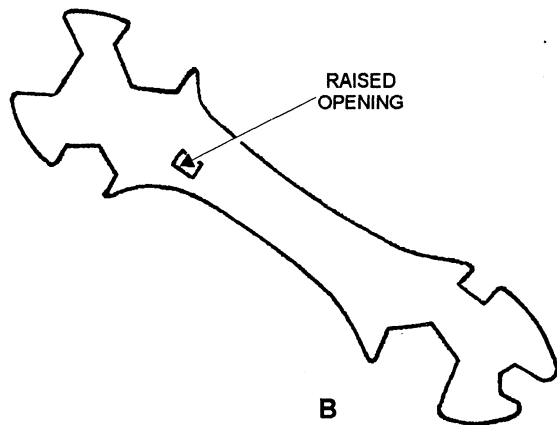
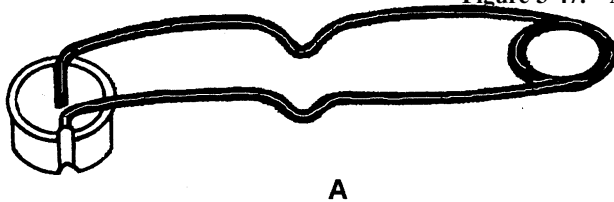


Figure 3-47.—An oxygas welding outfit.



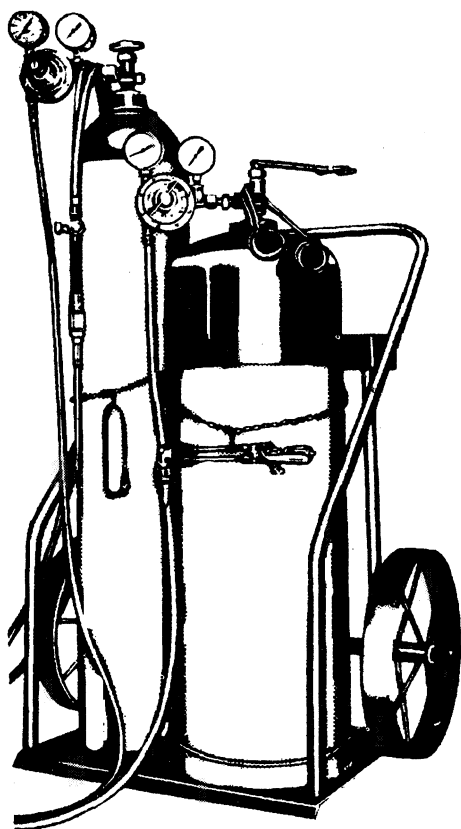
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Figure 3-48.—Auxiliary equipment.

Being a liquid, MAPP is obtained by the pound, rather than by the cubic foot, as with acetylene. One 70-pound cylinder of MAPP gas does the work of more than six and one-half 225-cubic-foot acetylene cylinders. This is a ratio of 70 pounds of MAPP gas to about 1,450 cubic feet of acetylene.

Total weight for the 70-pound MAPP cylinder, which is the same physical size of a 225-cubic-foot acetylene cylinder, is 120 pounds when full.

MAPP cylinders contain only liquid fuel. There is no cylinder packing of acetone to impair fuel withdrawal. For heavy-use situations, a MAPP cylinder delivers more than twice as much gas as an acetylene cylinder for longer periods of time. The entire contents of a MAPP cylinder can be used, since there is no acetone that could be drawn into the regulators or the torch. As the gas burns with oxygen, it produces a flame temperature of 5300°F (2927°C) and equals or exceeds the performance of acetylene for



UTB10049

Figure 3-49.—Portable oxygas welding and cutting outfit.

cutting, heating, and brazing because of its superior heat transfer characteristics.

Acetylene regulators, hoses, torches, and welding tips may be used without any significant disparity. Very often the same-size tip can be used for welding with MAPP gas as with acetylene. However, it is recommended that a tip one or two sizes larger be used

with MAPP gas for optimum results. Table 3-2 is a good guide to follow when you are using acetylene tips for MAPP-gas welding.

MAPP is not sensitive to shock, and it is nonflammable in the absence of oxygen. There is no chance of an explosion if a cylinder is bumped, jarred, or dropped. The cylinders can be stored for transporting in any position without danger of an explosive air pocket being formed. The characteristic odor, while harmless, gives warnings of fuel leaks in the equipment long before danger.

MAPP gas is not restricted to a maximum working pressure of 15 psig as is acetylene. In jobs requiring higher pressure and gas flow, MAPP at the full-cylinder pressure of 95 psig at 70°F (21°C) can be used safely.

WELDING AND BRAZING.—With MAPP gas, this requires some differences in equipment and technique.

Prepare steel to be welded with MAPP the same as for welding with acetylene. For metals thinner than 1/8 inch (3.1 mm), clean the metal to be welded well, either with a wire brush or a grinding wheel. When metal is thicker than 1/8 inch, bevel it first and clean it thoroughly.

Position the steel with a root opening equal to the material thickness when the work is thinner than 1/8 inch. If the metal is thicker than 1/8 inch, leave a gap equal to the diameter of the welding rod to be used.

Set the gauge pressure with the torch valves closed; if the metal to be welded is 3/16 inch (4.2 mm) or less, set the gas (MAPP) pressure at 2-3 psig and the oxygen pressure at 10-15 psig. When working with 1/4

Table 3-2.—Substituting Acetylene Tips for MAPP Gas Use

DRILL	INNER FLAME LENGTH	REGULATOR PRESSURE RANGE		MAPP GAS USE	METAL WIDTH
SIZE OF TIP	INCHES	MAPP GAS	OXYGEN	CFH	INCHES
72-70	1/4	1-2	5-6	1-3	1/32
65-60	7/16	1-3	5-6	2-4	1/32-1/16
59-54	5/8	1-5	6-8	3-8	1/16-1/8
49-48	1	2-8	8-10	5-18	1/8-3/16
43-40	1 1/8	3-9	10-12	6-30	3/16-1/4
36	1 1/4	5-10	10-15	6-35	1/4 -3/8

inch (6.2 mm) or thicker steel, set MAPP-gas pressure at 4-5 psig and oxygen pressure at 15-20 psig.

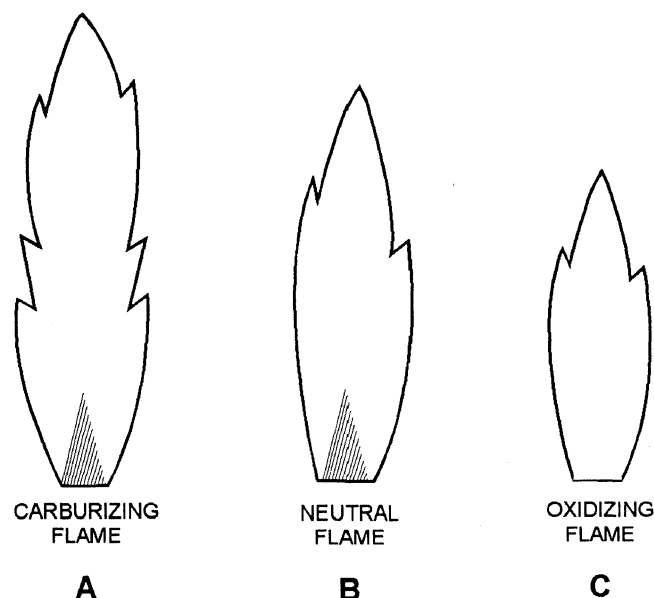
When indoors or in an enclosed area, you should light the torch by slightly cracking the gas valve on the torch. Light it with an approved friction lighter and then open the oxygen valve to obtain a neutral flame (very blue). This is best for welding outdoors or where there is a draft or when a smokeless flame is desired. Crack the oxygen and gas valves slightly, light the torch, and adjust it to a neutral flame.

Check the cone length and make sure the flame is neutral (fig. 3-50). **REMEMBER THE NEUTRAL MAPP-GAS FLAME IS LONGER THAN THE ACETYLENE FLAME.**

Flame adjustment is the most important step of successful welding with MAPP gas. As with all other fuel gases, there are three basic types of gas flames: carburizing, neutral, and oxidizing (fig. 3-50).

A carburizing flame looks much the same with MAPP as with acetylene. It has a yellow feather on the end of the primary cone. Slightly carburizing or reducing flames are used when you are welding alloys that oxidize easily, such as aluminum.

As the oxygen is increased or the fuel gas decreased, the carburizing feather pulls off and disappears, and the inner flame becomes a deep blue. This neutral flame (fig. 3-50) is ideal for welding. Increasing the oxygen flow produces a lighter blue flame, a longer inner cone, and a louder burning sound to give you an oxidizing MAPP-gas flame.



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Figure 3-50.—MAPP-gas flames.

Occasionally a harsh, bushy flame may be required for a job; in such cases, counterboring is needed to provide a harsh, yet stable, flame with MAPP gas.

Bulk MAPP-gas facilities, similar to liquid oxygen stations, are installed at some activities where large supplies of gas are used. In a bulk installation, MAPP gas is delivered through a piping system direct to the points where it is used. Maximum pressure is controlled centrally for efficiency and economy.

Cylinder filling facilities are also available from bulk installations that allow users to fill their cylinders on site. Filling a 70-pound MAPP cylinder takes one person approximately 1 minute and is essentially like pumping water from a large tank to a smaller one.

MAPP-GAS SAFETY.—Liquified MAPP gas is insensitive to shock. A MAPP-gas cylinder does not detonate when dented, dropped, hammered, or even incinerated. It may also be used safely up to full-cylinder pressure. The gas vapors up to 419°F and 285 psig do not decompose when subjected to an energy source in the absence of oxygen. The vapor is also stable up to 600°F and 1,100 psig when exposed to an 825°F probe. The explosive limits of MAPP gas range from 3.4 percent to 10.8 percent in air or 1.5 percent to 60 percent in oxygen. These limits are very narrow in comparison with acetylene (fig. 3-51).

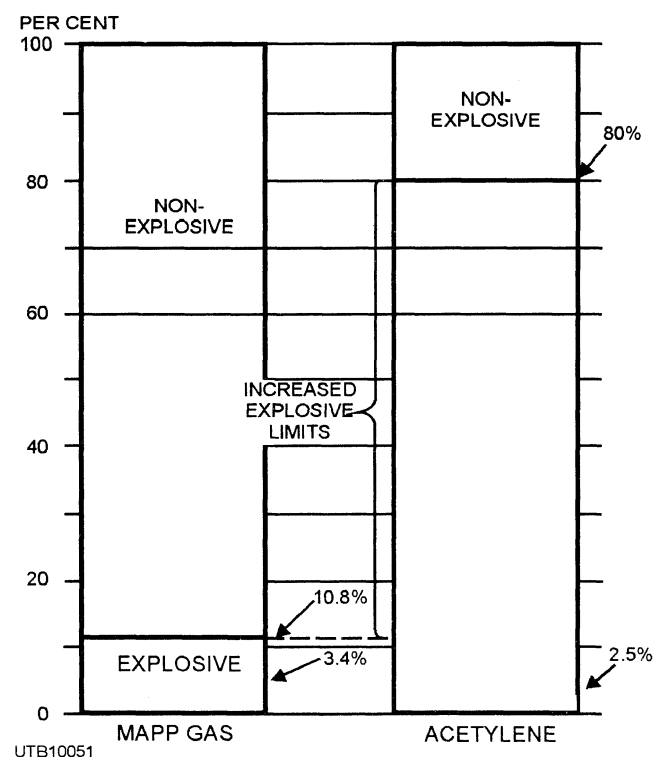


Figure 3-51.—Explosive limits of MAPP gas and acetylene in air.

MAPP gas has a detectable odor at 100 ppm or at a concentration 1/340 of its lower explosive limit.

Small fuel-gas systems may leak 1 or 1 1/2 pounds of fuel or more in an 8-hour shift; bulk systems leak even more. Fuel-gas leaks are often difficult to find and oftentimes go unnoticed; however, a MAPP-gas leak is easy to detect and can be repaired before it becomes dangerous.

MAPP toxicity is rated very slight, but high concentrations (5,000 ppm) may have an anesthetic effect. Local eye or skin contact with MAPP-gas vapor causes no adverse effect. The LIQUID FUEL MAY CAUSE DANGEROUS FROSTLIKE BURNS because of the temperature at which MAPP gas must be stored.

OXYGEN.—Oxygen is a colorless, tasteless, and odorless gas slightly heavier than air. It is not flammable but supports combustion with other elements. In its free state, oxygen is one of the most common elements. Rusting of ferrous (containing iron) metals, discoloration of copper, and corrosion of aluminum are all due to the action of atmospheric oxygen. This action is called “oxidation.”

When oxygen is supplied for use in oxyacetylene welding, oxygen is contained in seamless steel cylinders. A typical oxygen cylinder is shown in figure 3-52. Oxygen cylinders are made in several sizes;

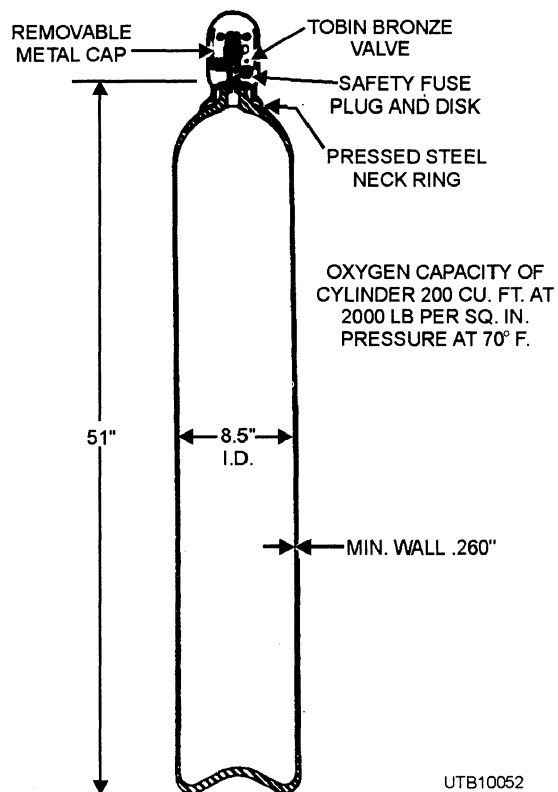


Figure 3-52.—Typical oxygen cylinder.

however, you will find the size most often used in welding and cutting is the 200-cubic-foot capacity cylinder. It is 9 1/8 inches in diameter and weighs about 145 pounds. This cylinder is charged to a pressure of 2,000 psi at a room temperature of 63°F (17.2°C).

You can tell the amount of oxygen in a compressed-gas cylinder by reading the volume scale on the high-pressure gauge attached to the regulator.

REGULATORS.—The gas pressure in a cylinder must be reduced to a suitable working pressure before it can be used. This pressure is reduced by a regulator or reducing valve. Regulators that control the flow of gas from the cylinder are either single stage or double stage. Single-stage regulators reduce the pressure of the gas in one step, while two-stage regulators perform the same work in two steps or stages. Generally, less adjustment is necessary when two-stage regulators are used.

Figure 3-53 shows two SINGLE-STAGE regulators: one for acetylene and one for oxygen. The

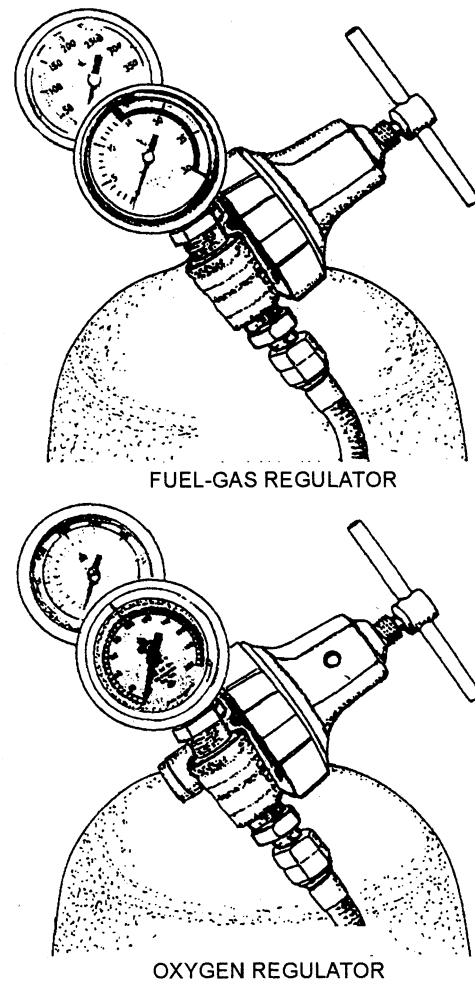


Figure 3-53.—Single-stage regulator.

regulator mechanism consists of a nozzle through which the high-pressure gases pass, a valve seat to close off the nozzle, a diaphragm, and balancing springs. These items are all enclosed in a suitable housing. Pressure gauges indicate the pressure in the cylinder or pipeline (inlet), as well as the working pressure (outlet). The inlet pressure gauge, used to record cylinder pressures, is a high-pressure gauge. The outlet pressure gauge, used to record working pressure, is a low-pressure gauge. Acetylene regulators and oxygen regulators are of the same general type, although those designed for acetylene are not made to withstand as high a pressure as those designed for use with oxygen cylinders.

In the oxygen regulator, the oxygen enters the regulator through the high-pressure inlet connection and passes through a glass wool filter that removes dust and dirt. Turning the adjusting screw IN (to the right) allows the oxygen to pass from the high-pressure chamber to the low-pressure chamber of the regulator, through the regulator outlet, and through the hose to the torch. Turning the adjusting screw to the right INCREASES the working pressure; turning it to the left DECREASES the working pressure. The high-pressure gauge is graduated in pounds per square inch from 0 to 3,000 and in cubic feet from 0 to 220. The gauge can be read to determine cylinder pressure and cubic content. Gauges are graduated to read correctly at 70°F (21°C). The working-pressure gauge is graduated in pounds per square inch from 0 to 150 or less, from 0 to 200, or from 0 to 400, depending upon the purpose of the regulator. For example, on regulators designed for heavy cutting, the working-

pressure gauge is graduated in pounds per square inch from 0 to 400.

The TWO-STAGE regulator is similar in principle to the single-stage regulator. The main difference is that the total pressure drop takes place in two steps instead of one. In the high-pressure stage, the cylinder pressure is reduced to an intermediate pressure. In the low-pressure stage, the pressure is reduced from the intermediate pressure to a working pressure. A typical two-stage regulator is shown in figure 3-54.

WELDING TORCHES.—The oxygas welding torch mixes oxygen and MAPP gas in the proper proportion and controls the amount of the mixture. at the welding tip. Torches have two needle valves: one for adjusting the flow of oxygen and the other for adjusting the flow of MAPP gas. Other basic parts include a handle, two tubes (one for oxygen and another for MAPP gas), a mixing head, and a tip. Welding tips are made from copper and are available in different sizes to handle a wide range of plate thicknesses.

There are two general types of welding torches: a low-pressure type and a medium-pressure type. In the low-pressure torch, also known as an injector-type torch, MAPP-gas pressure per square inch is kept at about 1 pound. The oxygen pressure ranges from about 10 to 40 pounds, according to the size of the torch tip. A jet of relatively high-pressure oxygen produces the suction necessary to draw the MAPP gas into the mixing head. The welding tips may have separate injectors in the tip. A typical mixing head for the

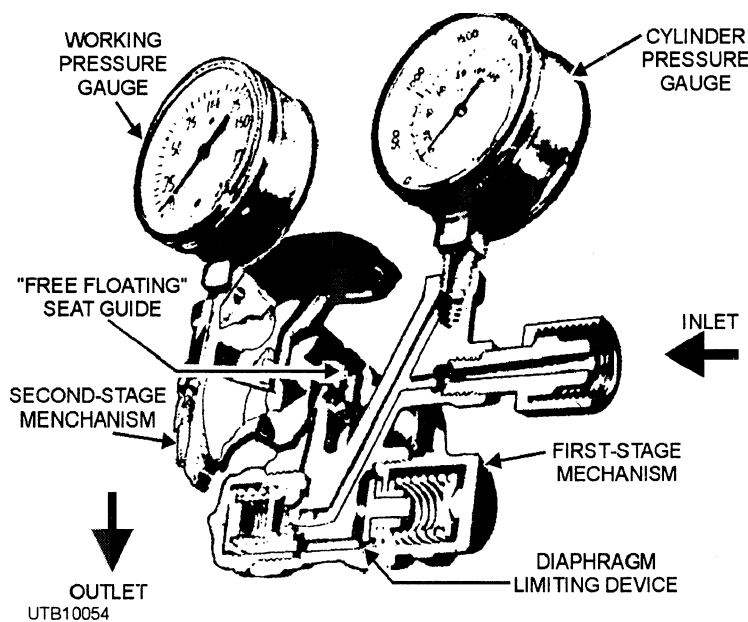


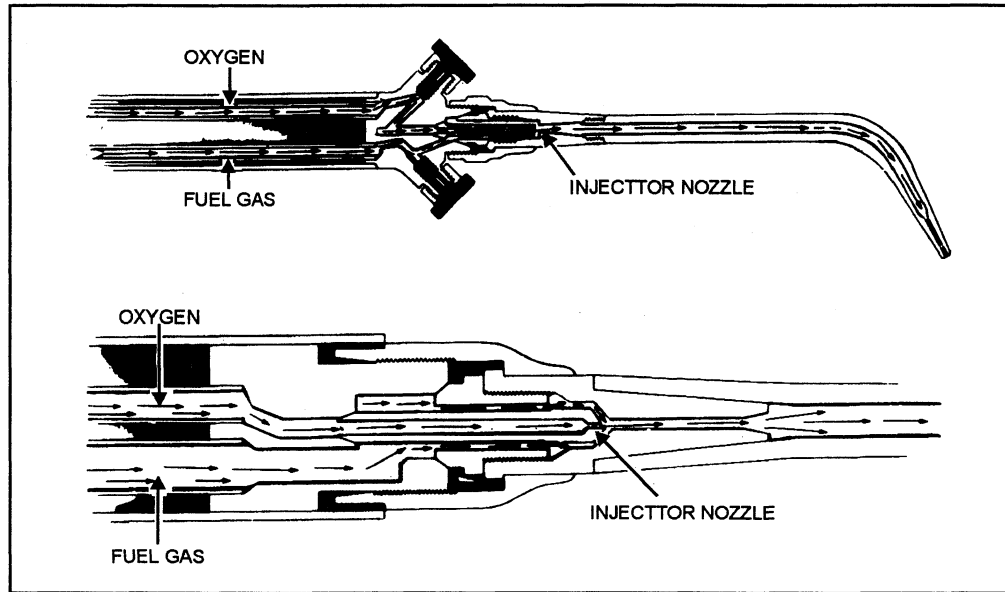
Figure 3-54.—Two-stage regulator.

low-pressure (or injector-type) torch is shown in figure 3-55.

Medium-pressure torches are sometimes called balanced-pressure or equal-pressure types, since the acetylene and the oxygen pressure are kept equal. Pressure per square inch may be from 1 to 6 or 8 pounds; **ACETYLENE PRESSURE MUST NEVER BE ALLOWED TO EXCEED 15 PSI.** A typical equal-pressure general-purpose torch is shown in figure 3-56. The medium-pressure torch is easier to adjust than the low-pressure torch and, since equal gas

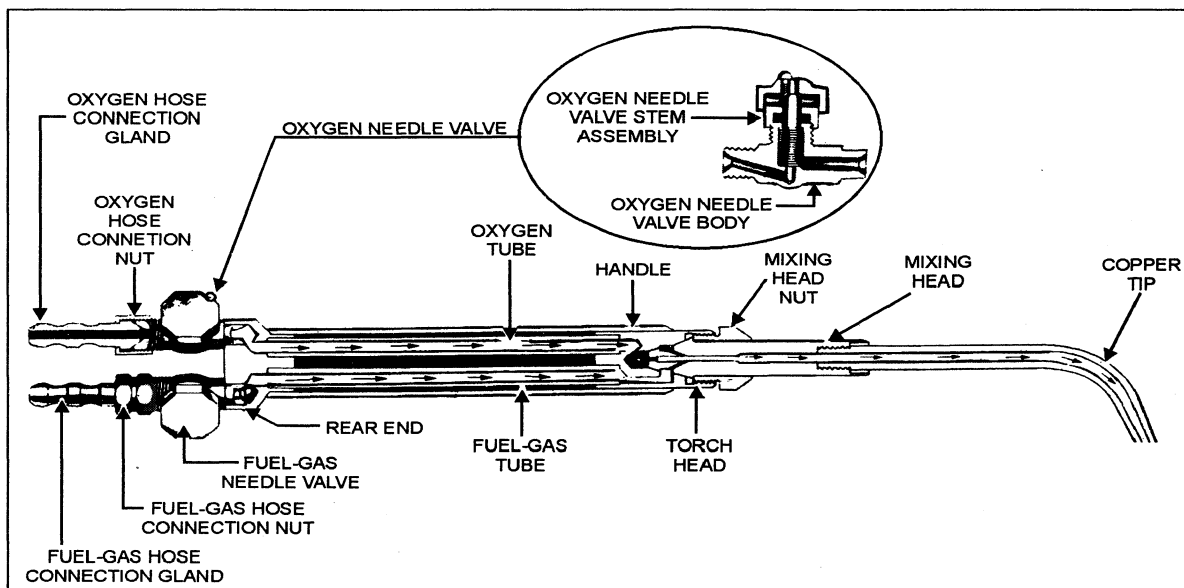
pressures are used for the medium-pressure torch, you are less likely to get a flashback; the flame is less likely to catch in or behind the mixing chamber. More details on flashback are provided later in this chapter.

Welding TIPS and MIXERS are designed in several ways, depending on the manufacturer. Some makes of torches have a separate mixing head or mixer for each size of tip. Other makes have only one mixer for several tip sizes. Tips come in various types. Some are one-piece, hard copper tips. Others are two-piece tips and include an extension tube to make connection



UTB10055

Figure 3-55.—Mixing head for a low-pressure torch.



UTB10056

Figure 3-56.—Equal-pressure welding torch.

between the tip and the mixing head. When the removable tips are used with an extension tube, they are made of hard copper, brass, or bronze.

Tip sizes are designated by numbers, and each manufacturer has an arrangement for classifying them. Tip sizes differ in the diameter of the hole to obtain the correct volume of heat for the work to be done.

HOSE.—Hose used to make the connection between a torch and a regulator is strong, nonporous, and sufficiently flexible and light to make torch movements easy. It is made to withstand high-internal pressures. The rubber used in its manufacture is specially treated to remove sulfur to avoid the danger of spontaneous combustion. Welding hose comes in various sizes, depending upon the size of work for which it is intended. Hose used for light work is 3/16- or 1/4-inch-inside diameter, and it has one or two plies of fabric. For heavy-duty welding and cutting operations, hose with a 5/16-inch-inside diameter and three to five plies of fabric should be used. Single hose comes in lengths of 12 1/2 feet to 25 feet. Some manufacturers make a double hose that conforms to the same general specifications. The hoses used for acetylene and oxygen are the same in grade, but they differ in color. Oxygen hose is GREEN; MAPP-gas hose is RED.

CAUTION

Use no oil, grease, or other lubricant on welding (or cutting) apparatus. Oil or grease in the presence of oxygen under pressure ignites violently!

FILLER RODS is the term that refers to a filler metal, in wire or rod form, for use in gas welding and brazing processes and certain electric welding processes when the filler metal is not a part of the electric circuit. A filler rod serves only one purpose; it supplies filler metal to the joint.

Filler rods for steel are often coated with copper to protect them from corrosion during storage. Most rods are furnished in 36-inch lengths and a wide variety of diameters, ranging from 1/32 to 3/8 inch. Rods for welding cast iron vary from 12 to 24 inches in length and are frequently square, rather than round, in cross section. The rod diameter selected for a given job is governed by the thickness of the metals being joined. Except for the rod diameter, the filler rod selected is

determined by military (MIL) specification on the basis of the metals being joined.

Many different types of rods are manufactured for welding ferrous and nonferrous metals. In general, welding shops stock only a few basic types that are suitable in all welding positions. These basic types are known as general-purpose rods.

SELECTION OF TORCH TIP.—Welding torch tip size is designated by a number stamped on the tip. The tip size is determined by the size of the orifice. There is no standard system of numbering welding torch tip sizes; each manufacturer has a numbering system. In this manual, tip size instructions are provided in orifice “Numbers drill” size. Number drills consist of a series of 80 drills, Numbers 1 through 80. Once you know a manufacturer’s torches and numbering system, you rarely have to refer to orifice number drill sizes.

Since the orifice size determines the amount of acetylene and oxygen fed to the flame, the orifice determines the amount of heat produced by the torch. The larger the orifice, the greater the amount of heat generated. For practical purposes with a balanced, pressure-type torch, use table 3-3.

If the torch tip orifice is too small, not enough heat is available to bring the metal to its melting and flowing temperature. If the torch tip is too large, poor welds result because the weld has to be made too fast. the welding rod melting is hard to control,

Table 3-3.—Welding Rod Sizes and Tip Sizes Used to Weld Various Thicknesses to Metal

Metal Thickness	Diameter Welding Rod*	Tip Drill Size
1/16	1/16	60-69
1/8	3/32	54-57
1/4	3/32-1/8	44-52
3/8	5/32	40-50
	3/16	
	3/16-1/4	
*Sizes listed in this table are approximate and provide satisfactory results. The size of the piece being welded will govern the tip choice. When welding small pieces, use a smaller tip and welding rod. When welding larger pieces, use a larger size tip and welding rod.		

and the appearance and quality of the weld are unsatisfactory.

SECURING OXYGEN WELDING EQUIPMENT.—To extinguish the oxygen flame and to secure equipment after completing a job, or to interrupt work temporarily, take the following steps:

1. Close the MAPP-gas needle valve first, then close the oxygen needle valve to extinguish the flame.
2. Close both the oxygen and the MAPP-gas cylinder valves. Leave the oxygen and MAPP-gas regulators open temporarily.
3. Open the MAPP-gas needle valve on the torch and allow gas in the hose to escape (5-15 seconds) to the outside atmosphere. Do not allow gas to escape into a small or closed compartment. Close the MAPP-gas needle valve.
4. Open the oxygen valve on the torch and allow gas in the hose to escape (5-15 seconds). Close the valve.
5. Close both oxygen and MAPP-gas cylinder regulators by backing out the adjusting screws until they are loose.

Follow the above procedures whenever your work is interrupted for an indefinite period. When work is to stop for only a few minutes, you do not have to secure the cylinder valves nor drain the hose; however, for any indefinite work stoppage, follow the entire extinguishing and securing procedures. For overnight work stoppage in areas other than the shop, it is safer to remove the pressure regulators and the torch from the system. Double-check the cylinder valves to make sure they are closed securely.

Maintenance of Gas-Welding Equipment

Welding equipment must be kept up if it is to work well for a long time. You do not have to make repairs to welding equipment; but when repairs are needed, see that the equipment is removed from service and turned in for repair. You are responsible for various duties in the maintenance and care of oxygen welding equipment. This section identifies some of the common types of maintenance duties that you can expect to perform.

Ensure welding torches are kept away from oil and grease. At times, the needle valve may fail to shut off when hand-tightened in the usual manner. If so, do not use a wrench to tighten the seat in the valve stem. When foreign matter cannot be blown off the seat, remove the stem assembly and wipe the seat clean before reassembling. Be sure and keep the mixer seat free of dust, dirt, and other foreign matter.

Before a new torch is used for the first time, check the packing nut on the valves to make sure it is tight. Some manufacturers ship torches with these nuts loose.

Welding tips get rough treatment at times. So keep the orifice smooth and clean if you want the tip to work well. When cleaning a welding tip, do not enlarge or scar it. Remove carbon deposits and slag regularly.

Avoid dropping a tip because the seat that seals the joint may be damaged. The flame end of the tip may receive mechanical damage if you let it contact the welding work, the bench, or the firebricks. This damage can roughen the end of the tip and cause the flame to burn with a “fishtail.”

Special welding tip cleaners have been developed to perform this service satisfactorily. The cleaner consists of a series of broachlike wires that correspond in diameter to the diameter of the tip orifices. These wires are packaged in a holder that makes their use safe and convenient. Some welders prefer to use a number drill that is the size of the tip orifice to clean welding tip orifices. A number drill must be used carefully, so the orifice is not enlarged, bell-mouthed, reamed out of round, or otherwise deformed.

The flame end of the tip must be clean and smooth. Its surface must be at right angles to the center line of the tip orifice for a flame that is shaped correctly. A 4-inch mill file is used to recondition this surface.

Should the end of the torch tip become rough and pitted and the orifice become bell-mouthed, recondition the tip. Place a piece of emery cloth, grit side up, on a flat surface; hold the tip perpendicular to the emery cloth; then rub it back and forth just enough to true the surface and to bring the orifice back to its original diameter.

If there is leakage around the TORCH VALVE STEM, tighten the packing nut, and repack it if necessary. For repacking, make sure you use only packing recommended by the manufacturer of the torch. **DO NOT USE ANY OIL.** If the valve stem

happens to be bent or badly worn, replace it with a new stem.

A symptom of LEAKY VALVES is a continuous flow of gases after the valves are closed. Leaky valves are often caused by a dirty or damaged seat. To clean the seat, remove the valve assembly and wipe the seating portions of both the valve stem and the valve body with a clean rag. If the leak continues, try closing the valve tightly several times. When these measures fail to stop the leak, you may have to replace parts, or the valve body may have to be resealed. These repairs should be made only by qualified personnel.

Leaks in the MIXING-HEAD SEAT of the torch cause oxygen and MAPP-gas leaks between the inlet orifices leading to the mixing head. This defect can cause improper mixing of the gases and result in flashbacks. This defect can be corrected by reaming out the seat in the torch head and by truing the mixing-head seat. You may have to send the equipment to the manufacturer for these repairs, since special reamers are required for truing seats.

With regulators, gas leakage between the REGULATOR SEAT and NOZZLE is a common type of trouble. This defect can be detected by a gradual rise in pressure on the working-pressure gauge when the adjusting screw is fully released or is in position after adjustment. Frequently, this trouble, known as CREEPING REGULATOR, is caused by worn or cracked seats. It can also be brought on by foreign matter lodged between the seat and the nozzle. Regulators with leaks across the seats must be repaired at once; otherwise, damage to other parts of the regulator or apparatus may result. Leaks are particularly dangerous in acetylene regulators because acetylene, at very high pressure in the hose, becomes an explosive hazard. To ensure the safety of personnel and equipment, see that regulators with such leaks are removed from service and turned in for repair.

Another important aspect of welding safety is protecting your eyes and the vision of helpers, chippers, or inspectors where someone is soldering or silver brazing. Ensure you are aware of hazards, such as stray flashes, reflected glare, flying sparks, and bits of molten metal. Ensure that you are using the proper eye protective lenses. If you are not sure, ask your crew leader or project supervisor.

For hand protection, you may have to use either gauntlet gloves or mitts. Some of the important safety precautions in working with acetylene and oxygen cylinders are provided below. Quite a number of

precautions apply to cylinders, so the following precautions are NOT a complete listing.

Store all cylinders carefully under prescribed storage procedures. Cylinders should be, stored in dry, well-ventilated, well-protected places, away from heat, and away from combustible materials: Do NOT store oxygen cylinders in the same compartment where acetylene or other fuel-gas cylinders are stored. All cylinders should be stored upright, rather than horizontally. If acetylene cylinders are not stored upright (valves at top), they must not be used until they have been allowed to stand upright for at least 12 hours to prevent acetone discharge. This tendency to discharge acetone depends largely upon the type of porous filler; however, 12 hours is ample time, regardless of the condition of the filler.

When the cylinder is empty, the letter *E* should be written on the cylinder with a piece of soapstone, keel, or crayon. Store empty cylinders separately from charged ones. Storage spaces must have adequate ventilation and must not be exposed to fire hazards, extremes of weather, continuous dampness, or accumulations of snow or ice.

Galvanized Pipe

The term *galvanized* means that wrought-iron and steel pipe are protected to resist corrosion. Wrought-iron and steel pipe are made in the same manner. Wrought iron is about twice the cost of galvanized steel, and it is used more for waste systems than for water service. Almost all steel and wrought-iron pipe are galvanized on the outside and on the inside at the factory.

Black iron pipe (not galvanized) is cheaper than galvanized pipe. Black iron pipe is suitable for heating (both steam and hot water) and compressed air systems. It is also used for gas and oil pipelines exclusively. Black iron pipe is NOT suitable for use, either in a water-supply system or a drainage system. This is because black iron pipe rusts and causes stoppages or leaks within a short time.

Galvanized wrought iron and steel pipes are cut, measured, and threaded in the same manner. Both types of pipe come in lengths from 18 to 22 feet. The 20-foot length is about average. These pipes are classified into weights, such as standard, heavy, and extra heavy and refer to the wall thickness of the pipe. The wall thickness is a factor that bears directly on the amount of pressure the pipe can withstand.

FITTINGS.—The fittings used on either wrought-iron or steel pipe are generally made of malleable iron or cast iron. There are two types of iron pipe fittings: the pressure type and the recessed type. To compare these two types of fittings, study figure 3-57.

The pressure type of fitting is the standard fitting used on water pipe. The recessed type of fitting, also known as a cast-iron drainage or Durham fitting, is generally required on all drainage lines. The recessed type is most suitable for a smooth joint; it reduces the probability of grease or foreign material remaining in the joint and causing a stoppage in the line. Recessed fittings are designed so horizontal lines entering them have a slope of 1/4 inch per foot.

Types of iron pipe fittings include elbows, crosses, tees, and unions. The four types of elbows are 90-degree, 45-degree, street, and reducing elbows. The 90-degree elbow changes the direction of an iron pipe 90 degrees, and a 45-degree elbow changes the direction by 45 degrees.

STREET elbows change the direction of an iron pipeline in a closed space where it is impractical to use an elbow and nipple. Both 45- and 90-degree street elbows are available. Street elbows have one female and one male thread, rather than two female threads.

The **REDUCING** elbow is similar to the regular 90-degree elbow, except that one opening is smaller than the other. For instance, a 3/4-inch pipe can be

screwed into one opening of this fitting and a 1/2-inch pipe into the other opening.

An iron pipe **CROSS** is made of malleable iron in straight and reducing patterns and has female threads at all four branch points.

A common type of iron pipe tee is the **STRAIGHT** tee which has a portion that is straight through and a 90-degree takeoff on one side. All three openings of the straight tee are of the same size. Another common type is the **REDUCING** tee, similar to the straight tee just described, except that one of the threaded openings is of a different size than the others.

There are two types of iron pipe unions. They are the ground joint union and the flange union. The **GROUND JOINT** union consists of three pieces, and the **FLANGE** union is made in two parts. Both types are used for joining two pipes together and are designed so they can be disconnected easily.

Other types of iron pipe fittings include couplings, nipples, pipe plugs, pipe caps, and pipe bushings. Each fitting is discussed briefly.

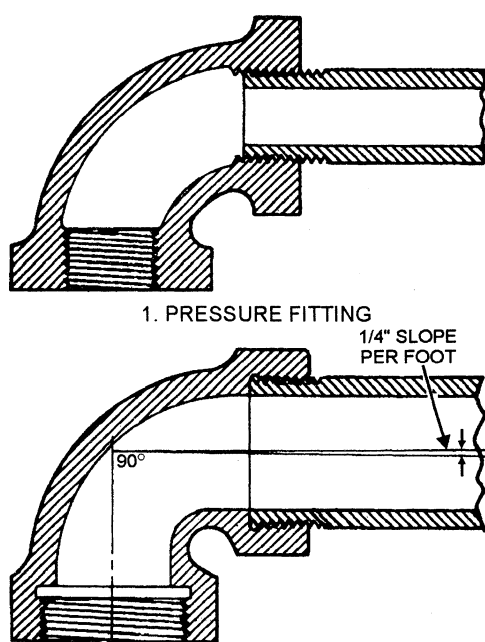
Three common types of couplings are straight coupling, reducer, and eccentric reducer (fig. 3-58). The **STRAIGHT COUPLING** is for joining two lengths of pipe in a straight run that do not require additional fittings. A **REDUCER** joins two pipes of different sizes. The **ECCENTRIC REDUCER** has two female threads of different sizes with different centers so, when joined, the two pieces of pipe are not in line with each other. It is installed to provide optimum drainage of the line.

A **NIPPLE** is a short length of pipe (12 inches or less) with a male thread on each end. It is used as an extension for a fitting. In plumbing work, nipples are often used. Nipples are available in many precut sizes. Figure 3-58 shows several common types of nipples.

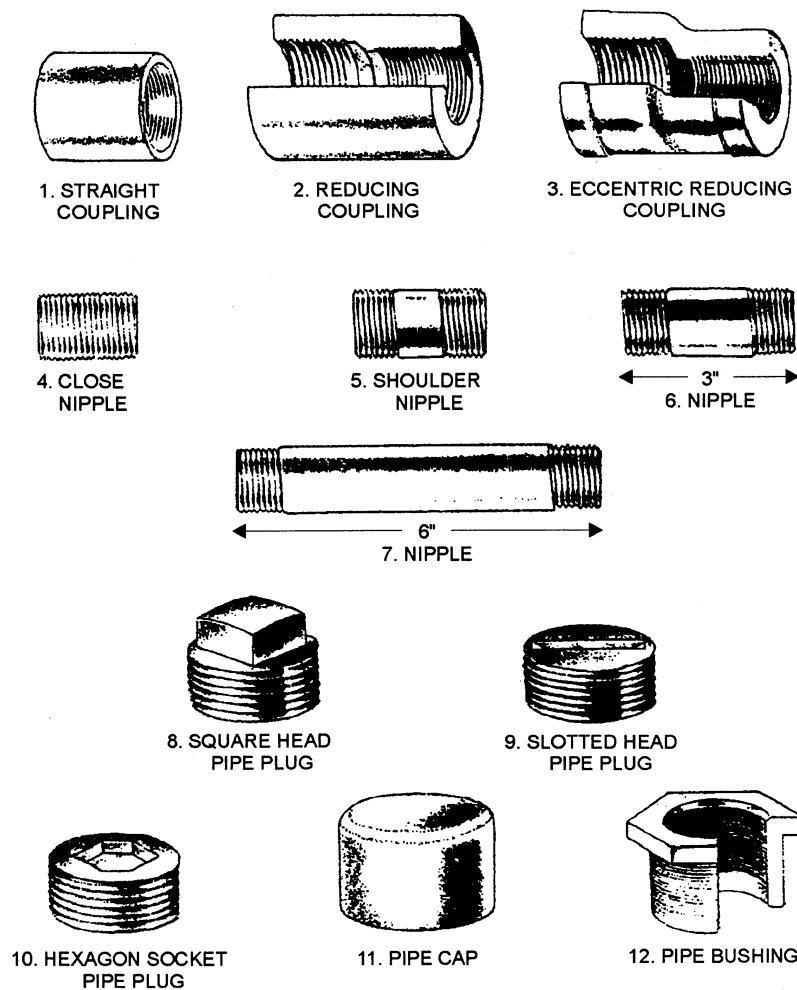
Pipe **PLUGS** are fittings with male (outside) threads. They are screwed into other fittings to close openings. Pipe plugs have various types of heads, such as square, slotted, and hexagon sockets (fig. 3-58).

A pipe **CAP** (fig. 3-58) is a fitting with female (inside) threads. It is used like a plug. It screws on the male thread of a piece of pipe.

A pipe **BUSHING** is a special fitting with a male thread on the outside and a female thread on the inside (fig. 3-58). Bushings reduce the size of openings of fittings and valves to a smaller diameter.



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Figure 3-57.—Pressure and recessed (Durham) fittings.



UTB10058

Figure 3-58.—Types of iron pipe couplings, nipples, plugs, caps, and bushings.

At times, you may use the **DIELECTRIC** or **INSULATING** type of fitting. These fittings connect underground tanks or water heater tanks. They are also used when pipes of dissimilar metals are joined. The purpose of dielectric fittings is to curtail galvanic or electrolytic action. The most common dielectric fittings are the union, the coupling, and the bushing.

READING THE SIZE OF FITTINGS.—To help you read the designations of fittings, you should know that each opening of the fitting is identified with a letter that indicates the sequence in reading the size of the fitting. As shown in figure 3-59, a cross with one end of run and one outlet reduced is designated as $2\frac{1}{2}(A) \times 1\frac{1}{2}(B) \times 2\frac{1}{2}(C) \times 1\frac{1}{2}(D)$. This is done simply by naming the largest opening first and then naming the other openings in the order indicated.

Elbows and crosses are always identified by designating the size of the largest opening first, following with the size of the other openings in proper

order. Tees, 45-degree Y-branches, and double-branch elbows are identified by designating the size of the largest opening on the run first, the opposite opening of the run second, and the size of the outlet last; for example, a $3 \times 2 \times 1\frac{1}{2}$ size tee is one that has openings $3(A) \times 2(B) \times 1\frac{1}{2}(C)$. In designating the outlets of side outlet reducing fittings, the size of the side outlet is named last. Refer to figure 3-59. The rules for reading screwed fittings also apply to reading other reduced fittings.

MEASURING.—Galvanized steel, galvanized wrought-iron, and black iron pipe are measured for size by the **INSIDE** diameter of the pipe. The outside diameter of the pipe remains constant for the different weights; whereas the inside diameter of the pipe varies because of the wall thickness of the pipe. The outside diameter is held constant because the pipe is normally joined by threaded joints, and one die can be used to thread any weight of one size. Also, fittings of a uniform size on the inside fit all the different weights

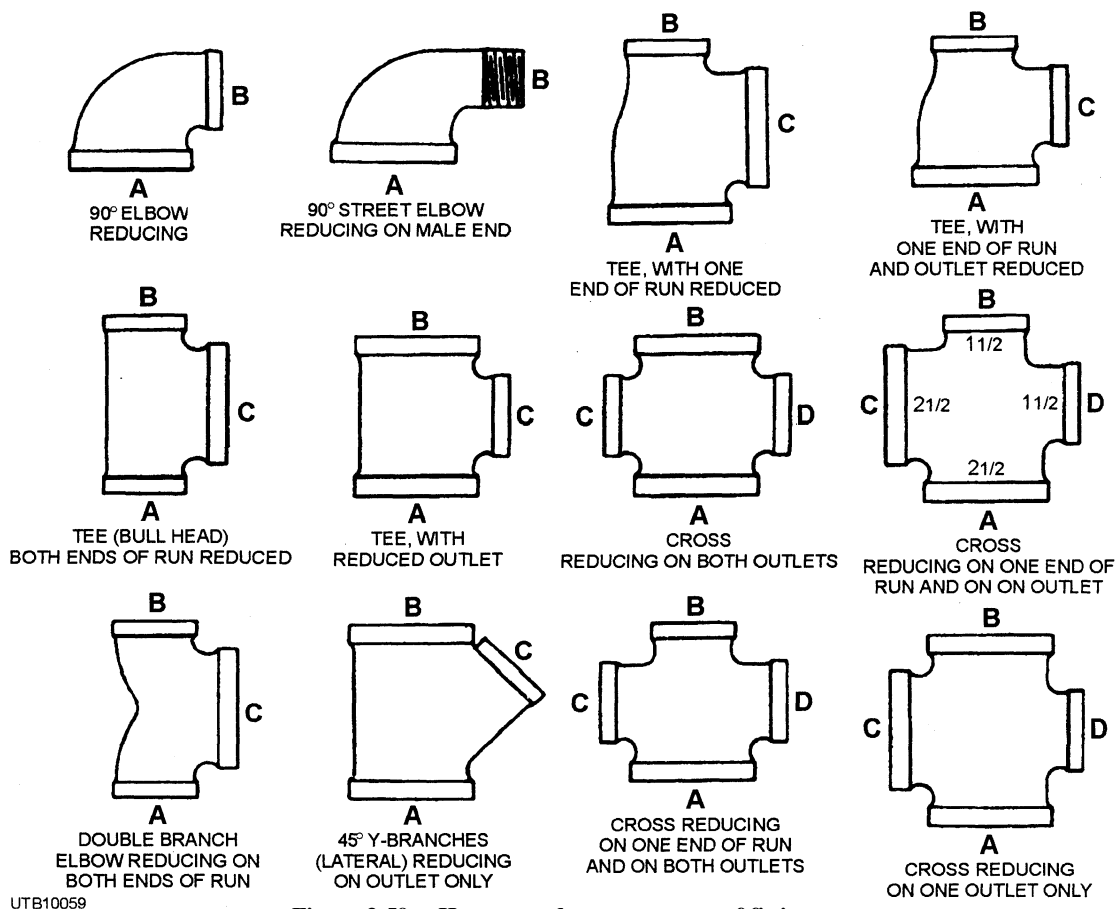


Figure 3-59.—How to read measurements of fittings.

of pipe. Threaded galvanized or black iron pipe is measured like copper pipe and tubing, as shown in figure 3-42.

CUTTING, REAMING, AND THREADING.—Galvanized pipe can be cut, reamed, and threaded by hand or with a power-operated machine. This discussion is limited to cutting, reaming, and

threading pipe with a power-operated machine. A power-operated machine saves time, especially when a large volume of material has to be cut. A typical electrically operated pipe machine (drive) is shown in figure 3-60.

In cutting galvanized pipe with the machine shown in the figure, insert the pipe into the machine. Then

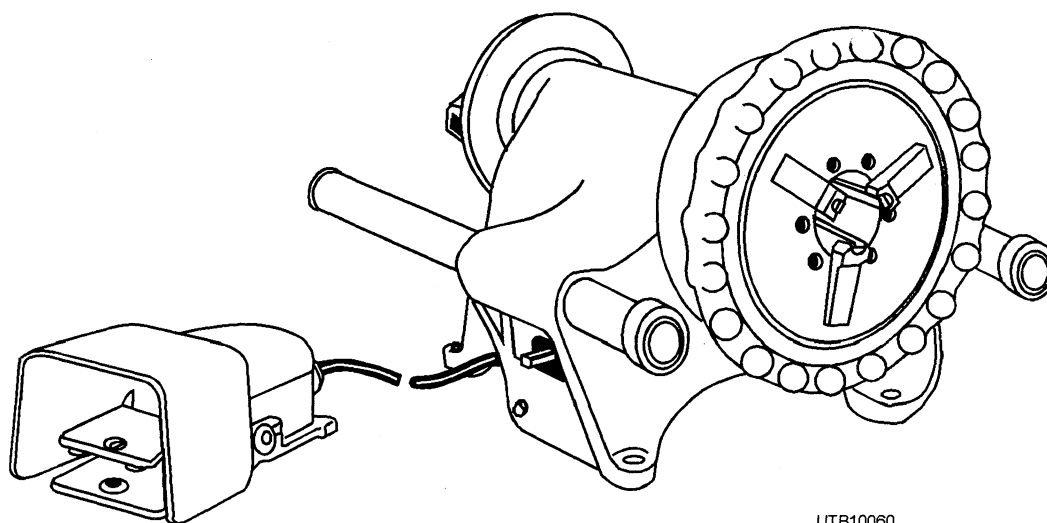


Figure 3-60.—Electrically operated pipe drive machine.

tighten the chuck jaws and rear centering jaws. Put the tool support bar in a position to support the cutter handle. Next, apply the cutter to the pipe as though you were cutting it manually. Let the cutter handle rest on the tool support bar. Ensure the cutter wheel is exactly on the mark where the pipe is to be cut. Now, tighten the cutter blade so it contacts the pipe. The next step is to turn the power switch to the FORWARD position. Continue turning the cutter blade into the pipe until the cut is completed.

After the pipe has been cut, it can be reamed with the same machine. To ream the pipe, place the reamer in the pipe end. Let the handle of the reamer rest against the tool support bar. Turn on the motor. Press the reamer into the pipe as needed to remove the burr.

The machine can also be used for threading pipe. First, insert the pipe into the front or the rear of the machine. Let the pipe extend out of the speed chuck far enough so the threader clears the chuck during threading. Next, center the pipe in the speed chuck and close the jaws with a snap spin of the handwheel. If the pipe extends out the back of the machine, close the rear centering jaws. Then place the threader on the pipe in the usual way. Pull out the tool support bar to the desired position and allow the threader handle to rest on the tool support bar on the switch side. Hook the safety latch over the handle. Now turn on the switch and proceed to thread the pipe. During the threading

operation, remember to use plenty of cutting oil. In addition to the machine shown in figure 3-60, figures 3-61 and 3-62 show other types of power pipe machines and their accessories.

JOINING.—THREADED PIPE JOINTS are used on galvanized steel, galvanized wrought-iron, and black iron pipe. This method of pipe joining involves connecting threaded male and female ends.

To obtain a tight-threaded joint, be sure the threads are clean and in good condition. If the pipe has been exposed to the weather or banged around, check the threads carefully. When necessary, run a die over the threads to straighten the damage.

After securing the pipe in a vise, you must clean both ends with a wire brush. Then apply a good thread lubricant on the male pipe threads. You should always use a Navy-approved nontoxic compound for water pipes or antisiezing tape and mixed powdered graphite and oil for steam pipes. Do not apply pipe dope inside the pipe fitting, or you will foul the system.

Start the joint by hand and turn it up as far as you feel it will go. Now, slowly screw the remaining section of the pipe into the joint and tighten it with a pipe wrench. Do not use a hickey, or oversized wrench, or too much pull. Not all of the male threads should be screwed into the joint. If all the threads are used, the

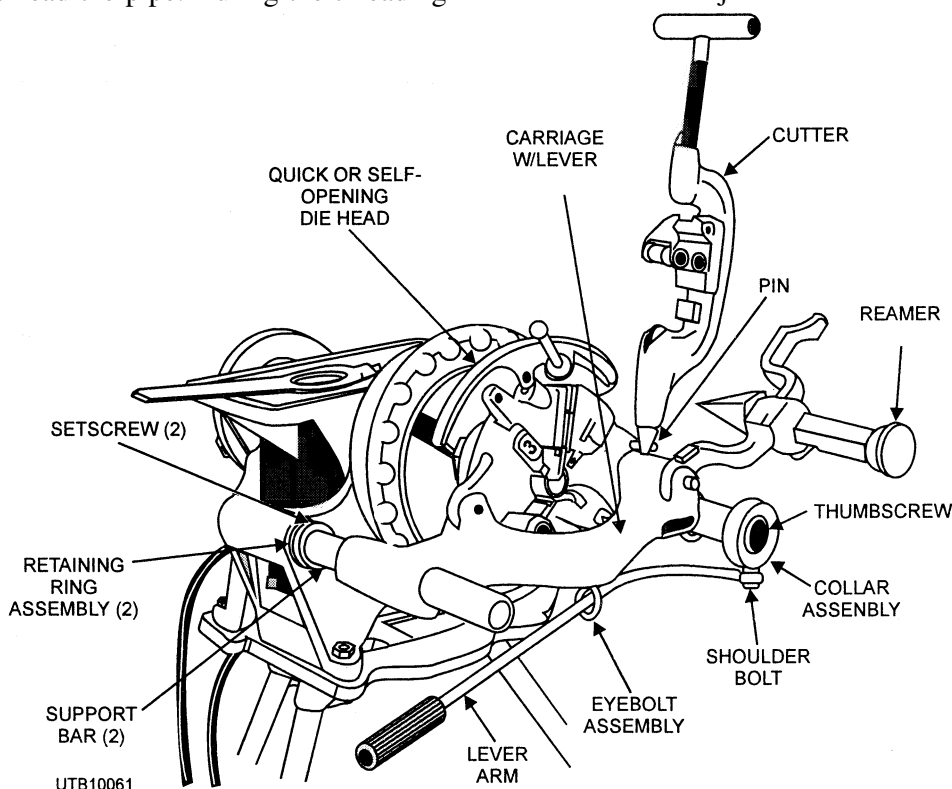


Figure 3-61.—Power drive with accessories.

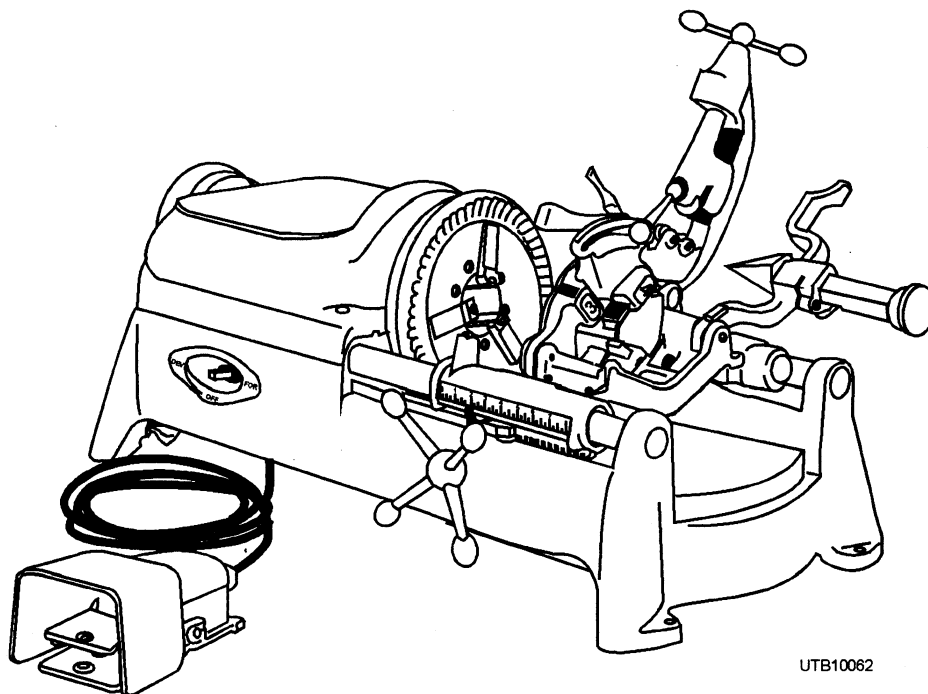


Figure 3-62.—Pipe- and bolt-threading machine.

wedging action of the tapered thread may cause the fittings to split. Usually there are two or three unused threads on a pipe that is threaded properly. If you follow the above steps and the threads are made properly, the joints will be tight for pressures several times the 150-psi working pressure of the fittings.

Cement-Asbestos Pipe

Cement-asbestos pipe is corrosion-resistant and does not rust or rot. It has a smooth interior surface that is a favorable friction factor. This pipe comes in sizes from 3 to 36 inches in diameter for pressures of 50 to 200 psi and in lengths of 5, 10, and 13 feet. Light in weight, cement-asbestos pipe is easy to handle. It is made with beveled ends, and adapters are available for connecting to pipe made of other materials.

FITTINGS.—In the absence of cement-asbestos fittings, you can use double-bell, cast-iron fittings and make them up as you would with cast-iron pipe, using sulfur compounds or lead.

CUTTING.—Cement-asbestos pipe can be cut to any length or angle with a carpenter's saw or a transite pipe cutter. Or, it can be tapped for threaded service connections by using a water main self-tapping machine. With this machine, the pipe can be tapped, threaded, and a corporation stop installed while the pipe is under water pressure.

Because of the health and environmental hazards associated with cement-asbestos pipe, special cutting and handling kits have been procured by the Navy and

are available through the naval supply system. Whenever cement-asbestos pipe is encountered, the base or unit environmental officer should be contacted. Also, the newest and most up-to-date instructions should be obtained and followed. Since safety procedures governing asbestos-related equipment change, an attempt to outline all the pertinent procedures for working with asbestos are not included in this manual; however, there are two important factors you should keep in mind. First, always wear a breathing filter or mask. Second, use water while cutting to keep the dust from becoming airborne, or use a vacuum to pull dust from the area of the cutting tool.

JOINING.—Joints in cement-asbestos pipe are made with a special coupling with three rubber sealing rings. Three rings are fixed in grooves at the factory, ready for assembly.

Figure 3-63 shows a cutaway view of a completed joint with the three rings in proper position. As each pipe moves into position during assembly, the rubber

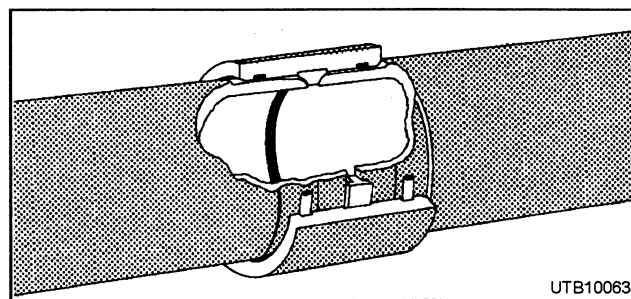


Figure 3-63.—Cutaway view of a cement-asbestos pipe joint.

rings in the two outer grooves of the coupling are compressed to seal the joint tightly. The T-shaped center ring forms a seal between the pipe ends to eliminate jogs and pockets and to provide for uninterrupted flow. In this type of joint, you have a tight and flexible connection.

A joint like the one shown in the figure can be assembled entirely by hand. After making sure the rings in the grooves of the coupling are in correct position, use the following two-step procedure, shown in figure 3-64, to make the connection.

1. Apply a thorough coating of lubricant to the male end of the pipe, all the way around (view A, fig. 3-64). If a special lubricant supplied by the manufacturer is not available, prepare a jellylike soap solution instead.

2. Pull or push the pipe together, as shown in view B of figure 3-64, and the joint is complete.

Ductile Iron Pipe

Ductile iron is cast iron in which the carbon is reformed by magnesium inoculation. This results in exceptional strength characteristics without otherwise

changing the basic nature of the cast iron. Because of this treatment, ductile iron has exceptional strength with good machinability, high impact, corrosion resistance, and great beam strength. For these reasons, ductile iron pipe is ideal for transportation of water.

When laying this pipe, you should ensure that both the bell and plain ends are clean. This is to prevent leaking joints. Sand, dirt, excess coating, ice, and other foreign material should be removed carefully from the plain end and the interior of the bell. This ensures proper seating of the gasket and correct entry of the plain end into the bell socket. The direction of the bells is not related to the direction of water flow within the pipe.

The mechanical joint for ductile iron pipe has four parts: a flange cast integrally with the bell of the pipe; a rubber gasket fitting a recess in the socket; a gland, or follower ring, to compress the gasket; and bolts and nuts for tightening the joint. The assembly of the joint is simple and requires only a wrench to tighten the nuts.

If the pipe must be cut, it may be cut with an abrasive wheel, a rotary wheel cutter, a guillotine pipe saw, a milling wheel saw, or an oxyacetylene torch. Of these cutting tools, the abrasive wheel saw is used most often for out-of-trench cuts; while the oxyacetylene torch method is used in trench cuts. Cut ends and rough edges should be ground smooth. For push-on type connections, the cut end should be beveled slightly.

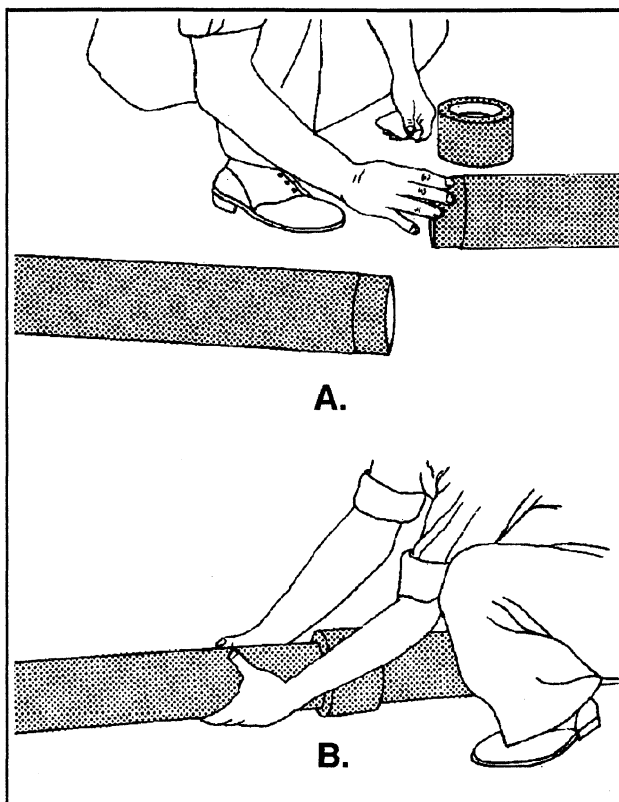
Because of the high-impact strength of ductile iron, you only need to remove rocks and boulders 8 inches or greater in diameter from the material to be used as backfill.

Concrete Pipe

An extremely dry mix of cement, sand, gravel, and water with or without additives is used and cast in steel forms to manufacture concrete pipe. Concrete pipe can be reinforced with welded wire fabric or rebar. It is normally a flared bell-and-spigot-type pipe, similar to cast-iron soil pipe, but in larger sizes, 10 inches and above. The bell and spigot have a smooth configuration.

FITTINGS.—The fittings are the same as cast-iron and vitrified clay pipe, using a flared bell-and-spigot joint, or a smooth bell and spigot. This joint is called the “slip joint.”

CUTTING.—A portable concrete saw is used to cut concrete pipe reinforced with steel. When cutting



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Figure 3-64.—Steps in assembling a cement-asbestos pipe joint.

with a concrete saw, ensure the pipe is on a solid base when cutting to avoid binding the saw. Also, use plenty of water to keep the blade cool. Never attempt to cut concrete pipe without proper personal safety equipment. Smaller sizes without reinforcement can be scored with a chisel, or “snap cut” like vitrified clay pipe. On larger sizes of pipe, 10 inches and above, cutting of the pipe is not practicable. Larger pipe is used in applications where cutting is not required.

JOINING.—Eight different types of joints for concrete pipe are available. The most common joint is the “slip joint”. This kind of concrete pipe joint is similar to the cement-asbestos pipe connection, except a coupling is not used. There is a groove on the spigot end where a rubber gasket ring is placed. This gasket is compressed into the groove by the bell of the connecting pipe as they are pushed together, forming a watertight seal. On pipe 10 inches in diameter and greater, cement mortar is placed in the spaces between the ends of the pipe on the outside; also inside, if the pipe diameter is large enough for access.

PVC-Class Water Pipe

PVC-class water pipe is used for construction projects around the world. It is lightweight compared to iron pipe, and it can also be cut easily and beveled with cement-asbestos tools. Most importantly, PVC-class water pipe can be joined together easily.

When installing this type of pipe, ensure the bell end, the plain end, and the gasket are free of dirt and debris. Usually, the company supplying the pipe also supplies a lubricant to facilitate the sliding of pipes together. When backfilling, ensure there are no rocks

or other hard debris in the backfill material, as they could, over a period of time, puncture the pipe.

One of the best reasons for using PVC pipe in a water main is the ease with which it can be tapped. A variety of adapters and valves are also readily available in the naval supply system.

- Q20. For water service applications, cast-iron soil pipe comes in what lengths?*
- Q21. Water pipes should be layed a minimum of how many feet above and away from sewer lines?*
- Q22. In water service, what type of copperpipe should be used for aboveground general applications?*
- Q23. What type of copper pipe comes in only 20-foot hand-drawn lengths?*
- Q24. There is a total of how many different methods of measuring pipe?*
- Q25. What is the end-to-center method of measuring pipe?*
- Q26. It is important to clean all the flux from a soldered copper pipe joint for which of the following reasons?*
- Q27. Black iron pipe should be used for what type of piping systems?*
- Q28. Because of the strength of ductile iron, you only have to remove rocks and boulders of what size from backfill material?*
- Q29. Joining of concrete pipe is similar to joining of what other type of pipe?*

